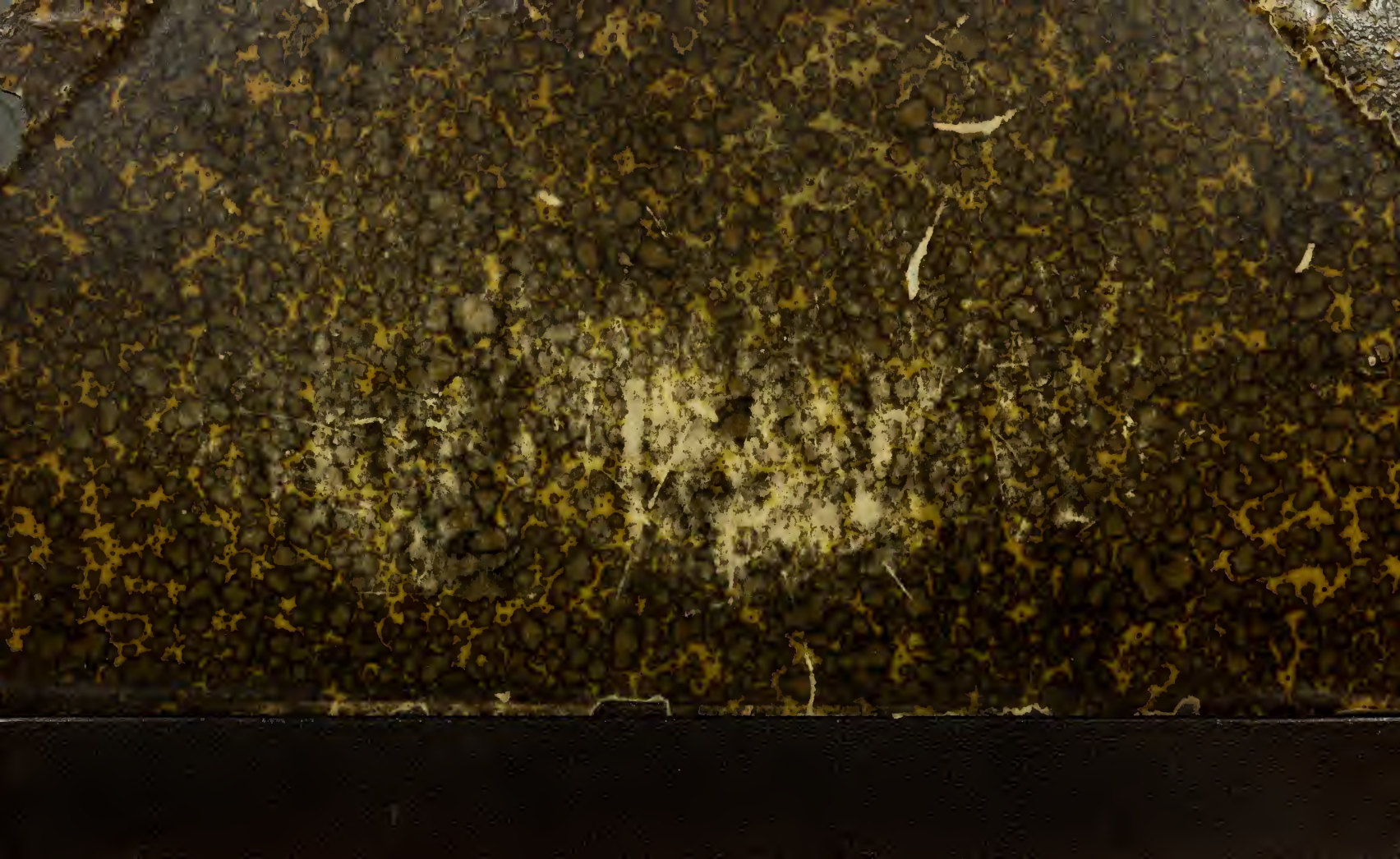

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Wisconsin Rye

AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF WISCONSIN
MADISON

DIGEST

Rye is a sandy soil crop. It conserves fertility; it is a hardy and vigorous grower; and it is a good soil binder. Pages 3–5

Rye is a good pasture and soiling crop. It grows so vigorously that judicious pasturing will not injure it and its rapid growth in spring makes it a favorite soiling crop. Pages 6–8

Rye is both a food and a feed. Next to wheat it is the cereal most widely used for human consumption. It is also quite widely used for feeding stock. Page 9

Rye production has been increased through breeding. The best varieties are from the Schlanstedt strain Pedigree No. 2, bred at the Madison station, and 12.19 from the Ashland station. Pages 9–12

Rye preserves soil fertility but does not add it. On the heavier soils rye takes the same place in a rotation as winter wheat. Pages 15–16

Rye has no insect enemies. Ergot is the most troublesome disease but this may be controlled by holding over the seed from one year to the next or by treating the seed with salt brine. Pages 18–19

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Wisconsin Rye

R. A. Moore and B. D. Leith

Rye is the most adaptable of small grain crops, which accounts for its growing popularity on Wisconsin farms. It is recognized as the grain best suited to light soils and to regions where winter killing is serious, but it adapts itself to rich soils and favorable climate. Where the yield in pounds is no greater than that of wheat or barley, however, rye can hardly compete with these crops as a market grain, since the market price per pound is somewhat lower. As a seed crop, pedigreed rye can compete with wheat and barley, even on the richer soils.

More acres of rye were produced in the United States in 1919 than in any previous year. More rye flour is being eaten in American homes now than ever before. There is now produced in the United States one-tenth as much rye as wheat; and the increase has been steady since 1914. In Wisconsin, the 1919 yield of over 8,000,000 bushels is the largest in the history of the state.

The area devoted to rye in Wisconsin has shown a steady increase over 1917. The largest production is in the central and northwestern parts of the state, especially on the sandy areas.

The average yields of small grains in the state over a period of four years shows rye to be the lowest producer, with barley leading in number of pounds per acre. (See Table I.) A ten-year average of the state shows the same condition to be true. However, the yields from the fields on the Hill Farm of the College of Agriculture, (See Table I) and also from the test plots of the Experiment Station Farm (See Table II) show rye to be the heaviest producer in pounds of grain per acre. The apparent discrepancy between the yields of rye on the Station farms and in the state as a whole is due to the fact that a great deal of the rye produced in the state is grown on sandy soils very low in fertility. The soil of the Station farms is a Miami silt loam in a fair state of fertility; and rye competes equally here with the other small grains.

Oats has yielded better than barley on this soil because evidently there was not sufficient fertility in the soil for a maximum yield of barley.

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TABLE I.—A COMPARISON OF ACRE YIELDS OF THE UNIVERSITY HILL FARM WITH THE AVERAGES OF THE STATE

	Winter rye		Winter wheat		Barley		Oats	
	Hill Farm	State	Hill Farm	State	Hill Farm	State	Hill Farm	State
	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu
1917	55.2	18.5	30.7	24.0	38.9	32.0	52.2	44.0
1918	32.2	17.6	26.9	21.2	52.2	35.7	56.0	46.6
1919	31.7	15.8	25.8	19.6	35.7	26.5	61.6	33.4
1920	41.2	16.0	29.7	22.0	35.0	31.7	79.2	44.8
4 yr. average	40.7	17.0	28.3	21.7	40.5	31.5	62.3	42.2
Lbs. per acre	2279	952	1698	1302	1944	1512	1994	1350

The foregoing table gives the average yields per acre of the leading small grain crops of the state compared with the production of the Wisconsin pedigree grains on the University Farm. The increase in yield on the University Farm is due largely to two factors, the increased producing power of the Wisconsin pedigreed grains, and the fact that several of the farms of the state are on poor soil and the fertility is not well kept up. The yields on the University Farm are no greater than any good farmer should expect to get, as the applications of fertilizer are not excessive.

The results shown in Table II are taken from the experimental plots. One twentieth-acre trial plots were first used and after

TABLE II.—COMPARATIVE ACRE YIELDS OF LEADING SMALL GRAINS ON THE EXPERIMENT STATION FARM, MADISON.

	1912 Bu.	1913 Bu.	1914 Bu.	1915 Bu.	1916 Bu.	1917 Bu.	1918 Bu.	1919 Bu.	1920 Bu.	9 yr. av.	Pounds per acre
WINTER RYE Pedigree 2 (Schlanstedt)	53.9	53.5	50.7	39.0	34.8	58.0	45.9	39.2	49.2	47.1	2,638
WINTER WHEAT Pedigree 2 (Turkey Red)	38.3	45.0	45.3	37.6	24.6	51.4	17.7	36.3	46.7	37.0	2,220
BARLEY Pedigree 6 (Oderbruck'r)	47.0	38.8	42.8	58.3	38.3	47.1	65.4	28.3	47.9	46.0	2,208
OATS Pedigree 1 (Wisconsin Wonder)	110.6	75.6	63.7	90.0	71.9	65.4	61.5	61.6	81.7	75.7	2,422

1915 the tests were made on one-fortieth acre plots in duplicate. The field used for test purposes is as uniform as possible in soil

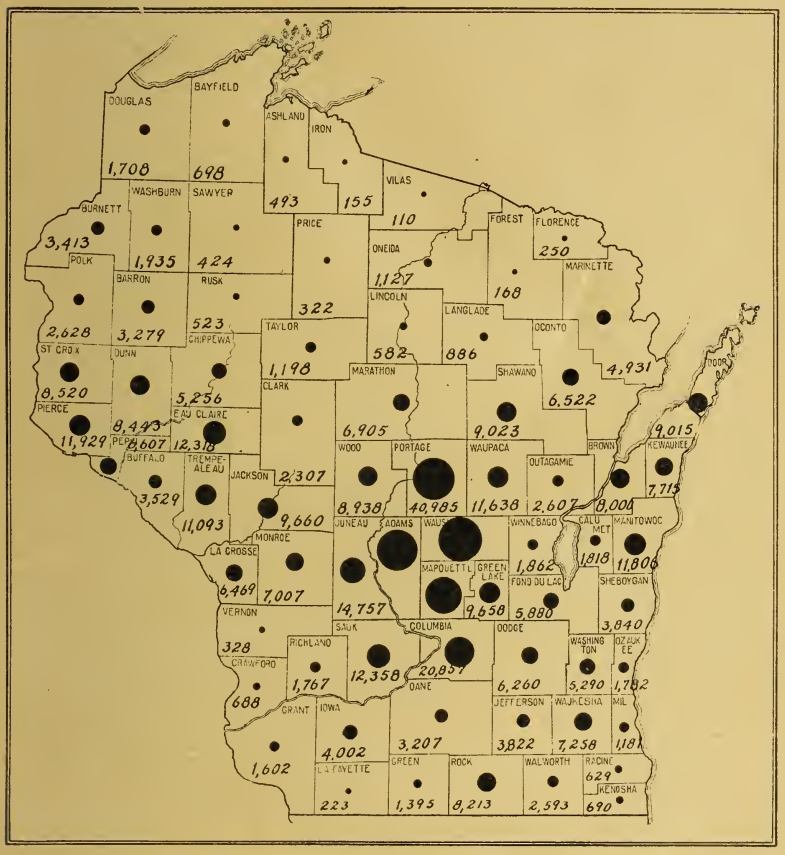

FIG. 1.—WISCONSIN ACREAGE OF RYE—1920
The largest production is in the central and northwestern parts of the state, especially on the sandy areas.

and fertility, and the small acreage used affords opportunity to test many varieties side by side.

WHY PLANT RYE?

Rye is primarily a sandy soils crop. Sown in the fall, it uses plant food that would otherwise be lost by leaching with the fall and early spring rains. Being a hardy and vigorous grower, it gets a good start in the fall and lives through the winter with little or no damage from winterkilling.

Rye is quite efficient in preventing blowing of soil, another reason for the favor in which the crop is held in light soil

sections. In areas where the force of the wind is especially great, however, even the deep root growth of rye may not be enough to hold the plants, and the rye may be torn away, roots and all.

FIG. 2.—VIGOROUS AND HARDY, RYE GROWS WELL ON LIGHT SOILS

Sown in the fall, rye makes a good growth before winter sets in, resisting winter-killing and using plant food that would otherwise be lost. On fairly good soils, as in this field, rye grows to be 6 feet in height.

Rye Is a Good Nurse Crop. It is off the ground very early, giving the young clover plants more opportunity to develop. It shades the ground very little. The leaves dry up some time before the grain is ripe, and the straw does not lodge easily.

Rye Is Double Purpose Crop. Rye sown for the grain is often used as a pasture crop. Many farmers plan the rye crop for both seed and pasture. They pasture until almost

heading time and, unless there is a very unfavorable season, they get a good crop of grain.

From rye sown in August a good growth will result the same fall, and pasturing will not be injurious to the crop. It may even be beneficial, if the growth has become very rank.

Sometimes spring pasturing is practiced. After the ground is firm there is little danger of damage from trampling. When rye is being used as a nurse crop the trampling may even be somewhat beneficial, in that it presses the seeds into the ground The rye yield will probably be reduced somewhat by spring pasturing, but the value of the pasture should make up for this loss.

Rye on Sandy Soil

Conserves soil fertility
Prevents soil blowing
Is one of the best nurse crops
Affords a good pasture and soiling crop
Is a good food for both people and livestock

If no clover has been seeded, the rye can be sown in the stubble of rye of the previous year just after the crop has been removed from the field. On a light soil with a single disc drill, the rye can be put in without any previous preparation of the soil. It will be in the ground in time to have a good chance to be sprouted by the late summer rains. An excellent fall pasture will result, and the bottom will be so thick usually that a good spring pasture can be had. On or before the middle of May, the rye that remains should be plowed under for green manure and the land planted to corn or soybeans.

The warm summer and fall rains release the nitrates in the soil as well as much of the phosphates and potash. The rye makes its growth on these elements, thus preventing their leaching out and being lost. In order to offset the fertility used for pasture, a light topdressing of manure is usually added during the winter. This plan combines a pasture and green manure without loss in fertility. If no topdressing is available, and the rye is to be used as a green manure, it is frequently inadvisable to pasture in the spring, as too much fertil-

ity is removed and the success of the following crop is doubtful. It has been found, however, that on the best lands in northern Wisconsin, including the Marshfield district, topdressing of the rye crop induces rank growth and consequent lodging.

Rye for Soiling. Where soiling is practiced rye is often used. Its early vigorous growth in spring makes it the best cereal crop for this purpose.

FIG. 3.—RYE IS A VALUABLE NURSE CROP

Rye is off the ground early, giving the young clover plants a chance to develop. The straw does not easily lodge.

Rye Is an Adaptable Crop. Rye has advantages in time of seeding that recommend it to farmers as an adaptable crop. It can be sown in this state from August 1 to November 1, considerably later than winter wheat can be sown. It is frequently sown to good advantage in corn or soybeans at the last cultivation. In the northern half of the state excellent results have been obtained by sowing after the corn crop was harvested for silage. There is no need of plowing in such a case and disking or spring-toothing, followed by harrowing, fits the ground. On sandy land the rye may be drilled in without previous preparation, especially after peas and soybeans. This method saves time, because there is no plowing, and it also has the advantage of controlling weeds. Yields of 20 to 45 bushels on fields of 5 acres and more have been obtained by such sowing

at Ashland, Spooner, Conrath, and Marshfield stations. Another crop which rye may follow is potatoes, or even roots. Rye is sown after the crop is harvested.

Rye As Food and Feed. Aside from the value of the crop in the farm rotation, rye is, of course, a valuable food and feed crop. In many European countries bread is made from pure rye flour, but in the United States a considerable amount of wheat flour is usually mixed with it. The pure rye flour makes a heavy, soggy loaf, with a strong rye flavor. Wheat flour has much more gluten, hence a mixture of wheat with rye makes a lighter loaf than the pure rye flour will make, and the rye flavor is not so strong.

Rye is often used as a feed for farm animals, but it should not be fed alone nor in large amounts, as it is likely to cause digestive disturbances. As a feed for swine, rye meal ranks a little below cornmeal and is about equal to barley meal. It should be fed with shorts, bran, ground oats, or ground barley. As much as 50 per cent of the feed may be rye meal, provided the feed with which it is mixed is not too heavy.

Fed in large amounts to cows, rye produces a hard, dry butter, but in limited amount and mixed with other feeds it has given good results.

In Germany from 2 to 4 pounds daily for each animal has been fed to horses, in combination with oats or barley, the grains preferably being crushed and mixed wih cut straw. Care must be exercised in feeding rye to horses, as colic is likely to result.

Rye straw is highly valued as a bedding for horses, as it makes a cleaner bed than other straws. It is used also for packing furniture, crockery, and nursery stock, and it is often used for stuffing horse collars. It is of little value for stock feeding, as it is woody and coarse.

Breeding Work Produces High-Yielding Rye

Practically all the rye grown in this state is Wisconsin Pedigree. This strain has been produced from four varieties: the Petkus, and Schlanstedt, introduced into the state from the United States Department of Agriculture in 1900; the Ivanoff, introduced in 1904; and the Minnesota No. 1, introduced in 1902.

These ryes were put into test plots to compare yielding power. Many of the finest heads were selected from each strain and planted to establish new lines. After discarding many plants and selecting the best for five years, a few of the very best remaining were finally pedigreed. In later tests further selections reduced the number to one pedigree line from each strain. Re-selections and further improvement determined that Pedigree No. 2, from the Schlanstedt is the best strain for Wisconsin.

FIG. 4.—HIGH YIELDS ARE OBTAINED FROM BRED-FOR-PRODUCTION GRAIN

Wisconsin Pedigree No. 2, which has been bred for 20 years at the Wisconsin Experiment Station, yields from 5 to 10 bushels an acre more than the best of the unpedigreed strains.

The 20 years of breeding put upon this rye have raised it to a high standard of excellence. Table II shows the yields of the pedigreed strains in the test plots. Pedigree No. 2, it will be noticed, has been tested for yield for 10 years, and the last 5-year average is 1.1 bushel higher than the first 5-year average.

Distribution of Pedigree Strains. The first dissemination of pedigree ryes was made in 1910 to the members of the Wisconsin Experiment Association. About 200 members tested these ryes the first year and 125 carried on tests in 1911. Reports showed an increase in yield of 6½ bushels, comparing Wisconsin pedigreed rye with the best other rye grown. Since that time rye has been sent out from the Wisconsin Experiment

Station to all corners of the state and to many other states and foreign countries.

A New Northern Rye. At the Ashland Branch Station, E. J. Delwiche has developed Pedigree No. 12.19, also a selection from the Schlanstedt, somewhat shorter in straw than the Pedigree No. 2. Being a good yielder it is finding much favor in the northern sections of the state. The yield reported on trial plots at Marshfield in 1917 was 63 bushels an acre and in 1918, 62 bushels an acre. Good yields were also obtained at Ashland, Spooner, and Conrath Stations.

Rye Facts

Wisconsin's 1919 rye crop of 8,069,000 bushels was the largest in the history of the state.

Rye is the hardiest small grain crop grown in Wisconsin.

Twenty years of selective breeding have been put upon the Wisconsin Pedigree No. 2.

Pedigree 12.19 is a promising new selection.

In a 9-year test on the Miami silt loam soil of the Station Farm at Madison, Wisconsin, pedigreed rye outyielded the other small grains in pounds of grain per acre.

RYE IS A VIGOROUS PLANT

The rye plant grows from 4 to 6 feet tall and stools profusely. It is deep-rooted and very hardy. The heads are long, slender, and nearly square. The kernels are ranged in two rows on either side of the head, protruding from the glumes. The color of rye kernels varies from green to yellow and brownish. They are quite soft in texture and make a darker flour than those from wheat.

The Rye Kernel. Little attention has been paid to the selection of rye for color of kernel in the United States. But the European breeders have recognized these color differences and have established green types, yellow types, types with little or no yellow, and a mixture of both. As a rule the American

rye miller discriminates against the green ryes as they make a darker, heavier bread with a strong rye odor.

The Wisconsin pedigree ryes are predominatingly yellow-kerneled with some mixture of green. The Rosen, recently developed at the Michigan Station is a greenish-kerneled rye. The Ontario Agricultural College has developed a yellow-kerneled rye which they call Mammoth White. This has not proved so high a yielder on the Station plots as the Wisconsin pedigree. So, even though it may be superior in appearance, it cannot be recommended for Wisconsin conditions.

How to Handle the Crop

Loose Mellow Seed Bed Best. The seed bed should be firm beneath, with 2 or 3 inches of loose, mellow soil on the upper surface. Some farmers sow the rye in corn at the last cultivation or in potatoes at the time of digging; others disk it in on the corn stubble. It is advisable to plow a week or two before planting so as to give the ground time to settle. Should it happen, as is often the case, that plowing cannot be finished until just before seeding time, firm the land with a roller as soon as possible after plowing.

This brings the particles of soil together and prevents drying out. The corrugated roller also leaves the surface in a fine mulch, thus preventing further loss of moisture through evaporation. On clay land where the ground is hard and lumps are turned up by the plow, it may be necessary to harrow at the close of each day's plowing. One or two harrowings well done may be enough compacting and pulverizing, and the use of the corrugated roller may not be necessary.

Rye Should Be Drilled. A drill places the grain deep in the ground, where it is more likely to obtain moisture. The slight ridges left by the drill also offer some protection in holding the snow in winter. The grain is quite uniformly covered at a depth of 2 or 3 inches, depending upon the looseness of the soil. This point is highly important in seeding on light soils. It is not advisable to harrow after the drill in fall seeding.

Heavy Seedings Do Not Pay. The usual rate of seeding rye is 1½ bushels an acre. On fertile soils an increase above this rate usually does not pay for the extra seed used. As a nurse

crop on sandy soils, rye should be sown at the rate of 3 pecks to 1 bushel an acre. The plant food in such soils is often so limited that it cannot support an ordinary rye crop and clover besides. A heavy nurse crop takes large quantities of moisture and shades the clover so much that, when the rye is cut, the sudden exposure of the clover to the hot July sun dries up the plants and may kill them.

It Pays To Plant Clean Seed. Rye should be carefully cleaned on the fanning mill. This removes weed seeds, light kernels, chaff, and straws, and often a considerable amount of ergot, leaving the large, plump kernels that will sprout and grow. (See page 19 for treatment to remove ergot.)

Rye will not germinate well immediately after harvesting. Three or four weeks resting period seems to be necessary before all the seed will grow. Before the planting time arrives, however, enough time will have gone by since harvesting to assure perfect germination.

FIG. 5—RYE MAKES A THICK STAND

The typical rye plant is tall, stiff-strawed, deep-rooted, and vigorous in growth. Its habit of profuse stooling gives thick stand.

Loss from Weathering Exceeds Cost of Stacking. Rye is cut with the self-binder, the same as other cereals. Particular attention should be given to protecting the shocks with cap sheaves, as warm

FIG. 6.—WELL-CAPPED SHOCKS ARE PROTECTED FROM SPROUTING

The rye harvest comes at a time when warm rains are likely to occur and cause sprouting. A shock well-capped to shed the rain, with some space within the bundles at the base to prevent smothering the clover seeding, is desirable.

FIG. 7.—GRAIN FROM SHOCK THRESHING REQUIRES CAREFUL HANDLING

If rye is threshed from the shock, the grain should be spread out where there is free circulation of air and watched carefully to prevent heating. This extra labor is only justified when the machine is ready to thresh the grain as soon as it is dry, thus getting the crop off the field earlier.

rains often occur about the time of rye harvesting and cause considerable sprouting. If the round shock is used, care must be taken to leave some space between the bundles at the base, or the clover seeding will be killed.

Stacking is preferable to shock threshing. As a rule, the damage from weathering in the shock is more than enough to pay for the trouble of stacking. Shock threshing is advised only when a machine can be had to thresh just when the grain is dry enough to stack. In this case, the greater amount of grain removed from the field in a day will justify the extra labor needed in handling the threshed grain.

The grain from shock threshing should be spread 1 or 2 feet deep on a floor where air circulation is good. It will need close watching so that prompt measures may be taken to prevent heating. If the weather is hot and somewhat damp the danger of heating is greater than usual. Whenever a rise in temperature can be noted in the grain, it must be shoveled over.

Rotations With Rye

On the heavier soils, rye takes the same place in a rotation as winter wheat. (See Bul. 305—Wheat Growing in Wisconsin.) On the light soils, the rotation is planned with the preservation of fertility in mind. Rye does not add fertility, but it is very valuable in preserving it.

The rotation given below is primarily intended to build up soil fertility on sandy soils:

1. Soybeans for seed or hay.
2. Rye sown early for green manure or pasture; to be topdressed in winter.
3. Corn or soybeans; plow rye under in spring.
4. Rye for grain; seed to clover in the spring.
5. Mammoth clover.

Where rye is grown primarily for the grain, this rotation is suggested:

1. Rye topdressed and seeded to clover in the spring.
2. Mammoth clover or medium red clover.
3. Corn or soybeans.

The second rotation introduces clover once in three years and there is a possibility of another legume crop, soybeans. Mammoth clover is suggested in preference to medium red, as it

thrives better on the sandy soils where building up fertility is important. Growing crops are on the ground practically the year around, making the fullest use of the fertility present. Pasture does not appear in this rotation, but some pasture can be had from the rye and some from the clover. Silage or soiling crops should furnish the rest of the succulent feed. On the sandy soils the problem of saving fertility does not admit the practice of a 4-year rotation wherein timothy can be grown with clover.

Rotation Used on Hill Farm at Madison

1. Rye, seeded to clover and timothy
2. Clover and timothy
3. Pasture
4. Corn

In this rotation rye is sown on the area from which silage has been removed. It is one of the best rotations in regions where dairying is practiced. It provides for pasture each year.

Rotation Used at Ashland Branch Station

1. Rye
2. Barley, oats, or spring wheat; seeded to clover
3. Clover
4. Cultivated crops
5. Peas

This rotation is suitable to regions where peas are grown profitably. As peas are removed early, the ground can be prepared for fall-sown rye without difficulty.

Rotation Used at Spooner Branch Station

1. Rye, sown after soybeans
2. Clover
3. Corn or potatoes
4. Soybeans

This is an excellent rotation for sandy soils as a legume is grown every second year.

GROW WINTER RYE IN WISCONSIN

There are winter and spring varieties of rye. Spring rye is not recommended, as the yield is not nearly so high as that of winter rye. (See Table III). This shows the average yields of two winter and two spring ryes.

TABLE III.—WINTER RYE OUTYIELDS SPRING RYE AT MADISON STATION FARM

	1918		1919		1920		Average	
	Yield per acre	Weight per bushel	Yield per acre	Weight per bushel	Yield per acre	Weight per bushel	Yield per acre	Weight per bushel
	Bu.	Lbs.	Bu.	Lbs.	Bu.	Lbs.	Bu.	Lbs.
Winter Rye.....	45.7	54.5	37.6	55.0	49.2	55.5	44.1	54.8
Spring Rye	31.1	53.7	17.2	49.2	23.5	39.4	23.9	47.4

Of the winter varieties the Schlanstedt, Petkus, and Ivanoff are the best known. The Abruzzes has found much favor in the South, but when tested out at the Madison Station it was completely winterkilled in the winter of 1917–18. Pedigree No. 12.19, which was bred at the Ashland Branch Station, is finding much favor in the northern part of the state. Pedigree No. 2 has made an excellent showing through a long period of years (see Table II). The Rosen rye has recently come into prominence, but a three years' test at the Wisconsin Station shows it cannot be considered equal in all respects to the Wisconsin Pedigree No. 2. The yields of the Rosen in some cases have been higher and in some cases lower. The average of four tests at the Madison Station give 37.2 bushels per acre for the Pedigree 2 and 32.6 bushels per acre for the Rosen. In 1918 the Rosen was very much damaged by winterkilling. As a result the grain was badly shriveled and of no value except for feed, and the yield was only 11 bushels per acre. As winter hardiness is one of the most desirable features of the rye crop in most parts of Wisconsin, it seems unwise to recommend a variety that is not exceedingly winter-hardy.

RYE CROP HAS FEW ENEMIES

Rye is comparatively free from damage by insects, and the only disease which causes serious damage is ergot. The black bodies which are sometimes found in the grain, or coming out in the head where the kernels should be, are ergot bodies—the resting stage of the disease. When planted with the grain, these bodies grow and cause further infection. The bodies are poisonous in either food or feed and will cause abortion if present in any quantity in the grain fed to animals. For this reason, ergot must be carefully removed in milling or the flour will be of poor quality. If much ergot is present, the flour will be poisonous.

Advantages of Winter Rye

Winter rye is far superior to spring rye
It can be sown with safety much later than winter wheat
It is not always necessary to plow for fall rye
Rotate and fertilize to get best results with rye
Rye is comparatively free from damage by insects and diseases

In many fields the damage from ergot is so small as to escape notice, but when once in the seed the disease increases until it becomes a menace to the crop. Fields have been found where every tenth or fifteenth head had ergot. An infection as heavy as this probably makes the crop worthless. The amount of damage cannot be judged solely by the number of black ergot bodies in the grain, as many kernels which appear normal, or nearly so, are blasted from ergot and will not grow.

Although the fanning mill takes out much of the ergot, the growths that are broken up in threshing are so nearly the size of the rye kernels that they cannot be graded out by the mill. No treatment that will not kill the seed will kill the disease. Holding over the seed from one year to the next is a good practice, since ergot loses its vitality at the end of a year and little or no disease results.

The salt brine method may be used for ergot.* The grain is

*See Wis. Cir. 94, Ergot in Rye and How to Remove It.

put in a concentrated brine solution and the affected kernels rise to the top where they are skimmed off. The seed is then washed to remove the salt. Small amounts of seed to be used in a seed plot can be treated in this way with little extra trouble. If sufficient seed for the next year's planting is grown in such a plot the ergot trouble can be entirely removed. Care must be exercised in the selection of a breeding plot, however, as many wild grasses carry ergot and the seed may become reinfected if the disease is on the grasses bordering the plot.

AGRICULTURAL EXPERIMENT STATION
THE UNIVERSITY OF WISCONSIN
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Bulletin 327 March, 1921

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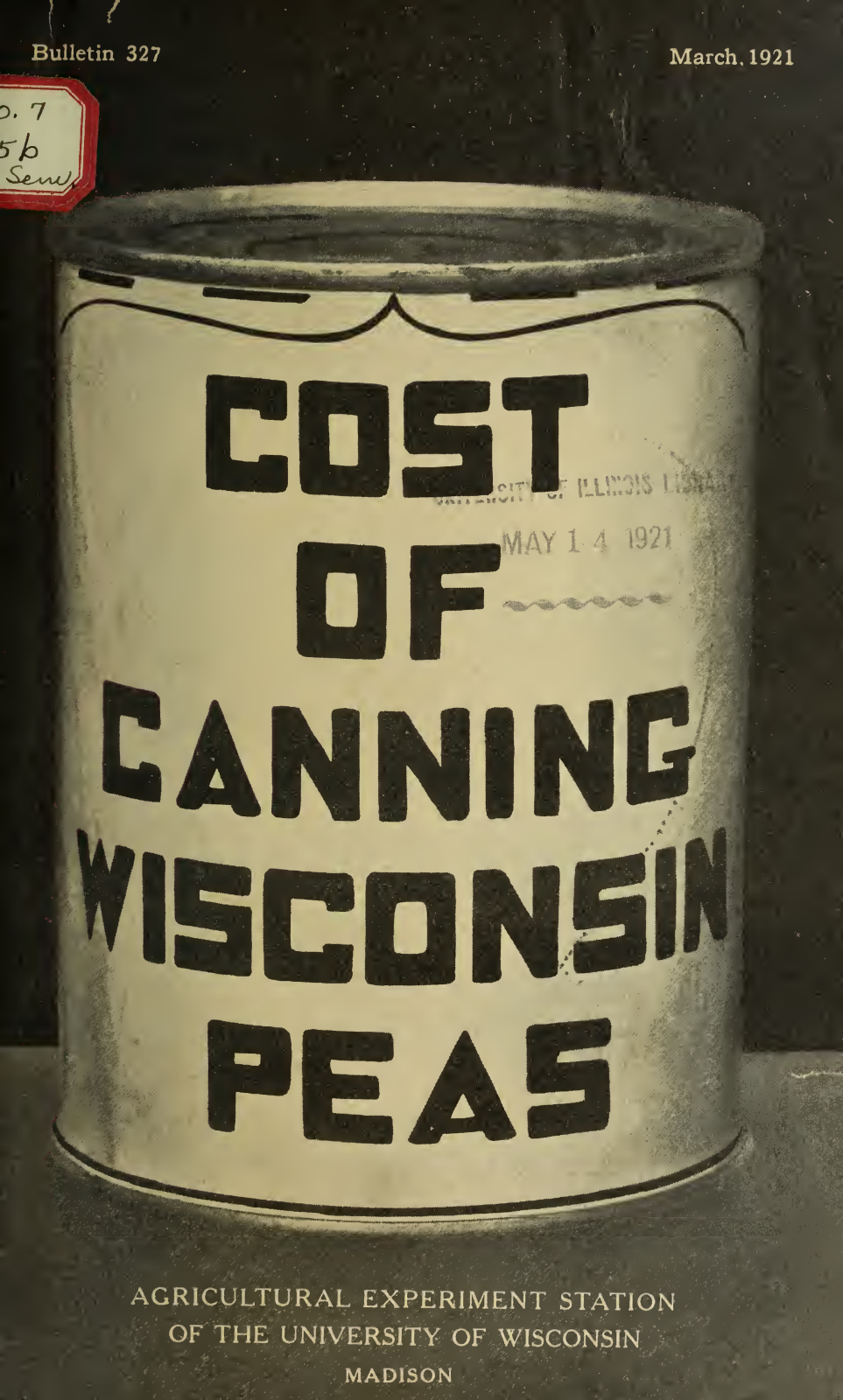

COST OF CANNING WISCONSIN PEAS

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AGRICULTURAL EXPERIMENT STATION
OF THE UNIVERSITY OF WISCONSIN
MADISON

DIGEST

Over $16,000,000 is invested in the pea canning industry of Wisconsin. Of this, farmers have $9,000,000 and canning companies $7,000,000. The value of the output of canned peas for 1919 was more than $12,000,000. Pages 4–5

High prices stimulated many new factories and brought Wisconsin to leadership in the industry. During the war, prices of canned peas were high because consumers wanted more peas than were produced. Page 5–6

Supplying the right amount of peas to consumers involves the payment of fair, proportionate prices to farmers, to manufacturers of containers and to pea canning factories for their mutual efforts in the industry. Pages 6–8

The establishment of new canning factories depends upon the level of prices which consumers will pay for the total annual pack of peas. While these prices continued high, it suggested a need for more factories. Now that the war is over and prices of peas have taken a disastrous tumble, those who plan new factories must consider whether a larger total supply of canned peas can be sold at remunerative prices. Page 8

Definite and dependable facts about costs and profits of growing and canning peas will increase demand and enlarge the industry. When consumers misunderstand basic production costs the tendency is to buy less than they otherwise would. Page 9

The production and canning of fancy or high quality peas requires skill in every detail. This necessarily demands the services of experts. Competition and demand for this grade of services compels payment of good wages and salaries. Pages 9–13

Pea canning is exceptionally hazardous. The ravages of disease and the effect of excessive rain or of unusually dry weather seriously affects either the quantity or the quality of the green peas and thereby influences the character and cost of the pack. Pages 13–16

The canning factory dollar was divided among several groups whose mutual efforts are essential to the making of a finished product for which consumers will pay. On the basis of one can No. 2 size, 3.05 cents were paid for peas, 3.22 cents for cans and boxes, 3.94 cents for maintaining and operating the factory, and 1.32 cents remained as the canner's profits. Pages 16–20

Pea canning, like farming, is a seasonal industry with a slow turnover. Competition makes a relatively wide margin of profit on each turnover necessary for both. Page 19

Cost of Canning Wisconsin Peas

THEODORE MACKLIN

WISCONSIN leads the United States in pea canning. To maintain this leadership it is important for both farmers and pea canners to be properly informed concerning costs, profits and other conditions throughout the industry. Wisconsin's 1919 pack of peas amounted to 4,317,000 cases or over 103,600,000 cans. This was almost one can for every man, woman and child in the United States. Facts from 22 factories out of the 88 plants in operation during 1919 indicate that consumers cannot consider canned peas a farm product only. The average cost of canning over 30,000,000 cans of peas was 10.21 cents each. This was distributed among farmers, can manufacturers, makers of box parts, and others whose services were required in making the finished product from the raw materials.

Factories sold their canned peas at an average price of $2.77 per case containing two dozen No. 2 cans. Out of the 11.53 cents received for each can of peas, the farmer or grower of green peas was paid 3.04 cents, cans cost 2.62 cents, boxes .6 cents, all other factory and selling expenses amounted to 3.94 cents, and profits of factories before income taxes were deducted, averaged 1.32 cents.[1] That containers—the cans and boxes together—cost 3.22 cents, or more than the green peas is a significant fact that both consumers and farmers have not fully realized before. Canned peas are as much a product of mines and forests as they are of farms. If consumers throughout the United States are to enjoy Wisconsin peas during every season of the year they must pay for cans and boxes as well as for the green peas. All other necessary costs must also be met by consumers if factories are to continue packing peas.

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[1] This profit is in terms of cents per can sold and not on capital stock. Some plants make money on capital when others do not. Hence per cent of capital may mean little when per cent of sales means much.

A SIXTEEN MILLION DOLLAR INDUSTRY

About 56,672 acres were devoted to the growing of peas for canning in Wisconsin in 1919 according to figures from pea canning factories.[2] Four-fifths of this land was owned and cul-

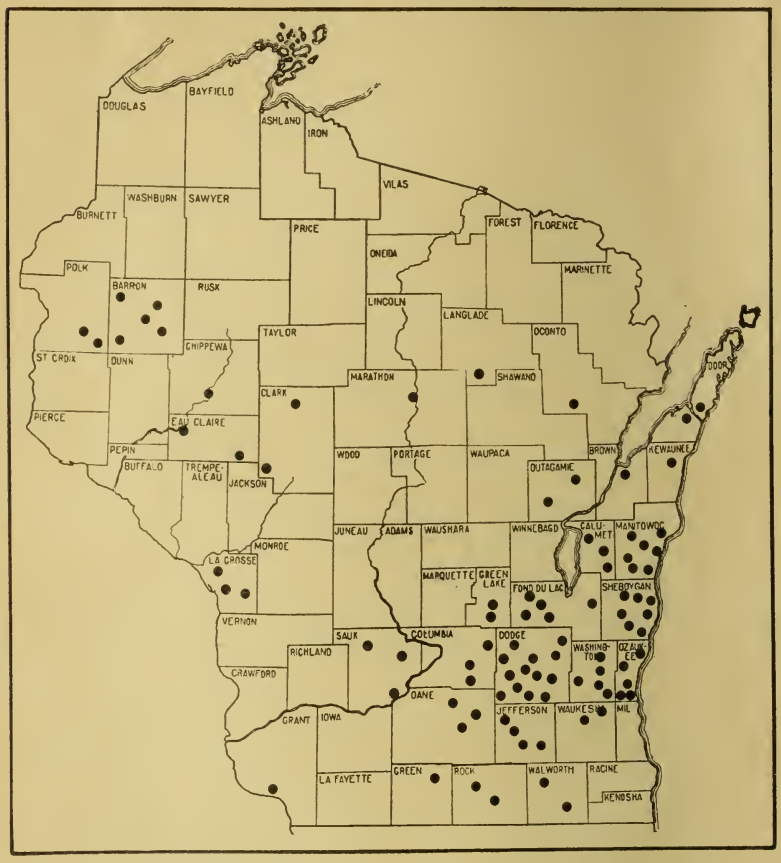


FIG. 1.—LOCATION OF WISCONSIN PEA CANNING FACTORIES

Each dot is a factory. All together these plants produce one-half of the canned peas of the United States annually.

tivated by farmers; one-fifth was owned and cultivated by pea canning companies. At a valuation of $200 per acre, farmers

[2] All of the factories canning peas in Wisconsin were invited by the Wisconsin Agricultural Experiment station to answer questionaires and to submit copies of their operating statements showing complete cost analyses for their business. Only 22 plants out of 88 factories in operation during 1919 submitted answers and cost figures.

had $9,099,200 worth of land devoted to the growing of peas, while the canning companies had $2,235,200 worth of land for the same purpose. The total paid-up capital of the 88 factories, which includes their land just mentioned, is estimated at $7,026,976 based on the average of $79,852 for 19 factories reporting. Beside their fixed capital, canners are heavy borrowers of short time loan money to finance their business. Probably not less than $16,126,176 worth of land, buildings, and equipment—representing permanent investment—was utilized in producing the 1919 output of Wisconsin canned peas while some millions of dollars of short time loans were also utilized. The factory value of the 4,317,000 cases was approximately $12,000,000 or $2.77 a case. Pea canning from the standpoint of both farmers and factory managements is, therefore, one of the important industries of the state.

Demands of Consumers Stimulated Pea Canning

During ten years, from 1910 to 1919, the output of canned peas for the United States doubled while Wisconsin's output increased four times. This rapid growth was due to the fact that consumers wanted peas and paid prices high enough to stimulate both the establishment of new canning factories and the growing of increased acreages of peas by Wisconsin farmers. The value of canned peas increased from $1.97 to $2.88 a case according to facts covering the operations of six plants for five years. It was in response to these increased prices that new pea canning factories were started and that farmers were paid more for their green peas.

Table I.—Time of Establishment of 21 Pea Canning Plants

Period	Number	Per cent
1900 to 1904	4	19
1905 to 1909	2	10
1910 to 1914	8	38
1915 to 1919	7	33
Total	21	100

Out of the 21 canning factories reporting their date of commencing business, 15 started operations since 1910 and only six

previously. (See Table I). One-third of the plants were established between 1915 and 1919. In fact, four companies operated for their first season in 1919. In no other year were more than two new plants opened for business. The growing demand for canned peas was therefore stimulating more and more factories to engage in the business of providing a more nearly adequate supply of this food product for the buying public.

Wisconsin farmers contributed to the growth of the industry by cultivating larger acreages of peas in response to higher prices for the green product. Out of 22 plants only six gave complete information covering a five-year period. Their facts —shown in Table II—indicate that farmers increased their acreages of peas in response to the rising prices paid by the canning companies. That the output of peas did not necessarily correspond to the increased acreage grown emphasizes variable yield as one of the peculiar hazards of the pea industry. In 1918, farmers supplying these six factories were fortunate in having an unusually high yield averaging 2,448 pounds per acre. In 1919 the yield from a greater acreage was only 1,709 pounds per acre.

TABLE II.—PEA ACREAGE INCREASED WITH RISING PRICES[1]

Year	Average prices per pound paid farmers for green peas	Acreage of peas grown by farmers	Pounds of peas produced by farmers	Per cent increase in price over 1915	Per cent increase on acreage over 1915	Per cent increase in peas over 1915
	Cents					
1915....	2.023	3,978	8,408,751	.....	.....	.....
1916....	2.004	4,096	8,056,220	.9[2]	2.8	4.2[2]
1917....	2.086	4,316	8,441,588	3.1	8.4	.4
1918....	2.770	4,736	11,597,057	36.9	19.0	37.9
1919....	3.268	5,087	8,695,422	61.5	27.7	3.4
Av.....	2.460	4,443	9,039,807	21.6	11.6	7.5

[1] Facts shown are the totals or averages from six plants which operated during all of the five years—1915 to 1919.
[2] Decrease.

RELATION OF PRICES TO QUANTITY OF PEAS

In spite of the rapidly increasing number of new canning plants and the increased acreages grown by farmers, not enough peas were canned to satisfy all consumers. When the demand

for a product cannot be met, prices are high because people who have the means bid prices high enough to assure themselves a supply of what they want. Precisely this has happened to peas. Prices rose and thereby stimulated higher production. It should not be overlooked, however, that the production of canned peas requires three essentials. Farmers must be induced to grow green peas; manufacturers of cans and boxes must be stimulated to provide containers; and canning factories must be built and operated. In the absence of any one of these

FIG. 2.—AT THE VINING STATION.

Here farmers dispose of their peas and machinery commences the complicated work of preparing and canning.

conditions no important quantity of peas can be placed on the markets of the country. To induce each one of these groups to do its part fully and efficiently necessitates that farmers, can and box manufacturers, and canning companies each receive a stimulating share of the factory selling value of the finished goods. If an insufficient price is paid by the canning company for green peas, farmers will produce less than enough to meet the needs of consumers. If too much is paid, the profits of canning companies will be so low that new factories will not be built and the output of this food will continue to be less than the amount desired by consumers.

OUTPUT DEPENDS UPON NUMBER OF FACTORIES

If the demands of consumers are to be satisfied, both producers and finishers of raw material should receive fair shares of the value of the finished product. Under present conditions, canning factories can economically put up the peas from limited acreages only. While the number of acres of peas grown per canning plant varied from 225 to 1,631 in Wisconsin, the average acreage for 18 concerns was 644 acres in 1919. An average of 517 acres per factory were cultivated by farmers, while the companies themselves directed the cultivation of an average of 127 acres per factory. Because canning factories are able to can the peas from a limited acreage only, any greatly increased output of canned peas may be brought about only by establishing new canning factories and stimulating new groups of farmers to supply them with green produce.

PROFIT STIMULATES ESTABLISHMENT OF PEA CANNERIES

During the war, consumers demanded ever increasing quantities of canned peas and paid remunerative prices for them. In response to the rising prices for green peas, farmers produced enough raw material to bring Wisconsin to first place as a pea growing state. Moreover, the profits of canning companies were sufficiently high to cause the establishment of many new plants some of which were built and operated by farmers cooperatively. Any one could enter the pea canning business, whether private or cooperative, and make good profits. This has been the direct result of a strong consumer demand which gave prices that were stimulating alike to canning companies, to manufacturers of cans and boxes, and to farmers. So long as these same stimulating conditions persisted it was almost certain that new plants would be started to provide new groups of farmers with a means of supplying consumers with greater quantities of peas. When these stimulating conditions cease, all concerned with pea canning may well examine the cause and find whether consumers are unwilling to pay remunerative prices to obtain either the same or an increasing supply. If either the same or a reduced supply is needed, it is also certain that new factories no longer will be desirable. Such a situation might readily develop by a fall in profits due to competition of pea canneries to dispose of any supply produced in excess of what consumers need.

MISUNDERSTANDING OF FACTS INJURES MARKET

Because the costs of canning peas involve practically equal payments to farmers, to can and box manufacturers, and to pea canning concerns, it is economically desirable that these costs should be more widely known. Few persons realize that the cost of cans and boxes exceeds the value of the canned peas they contain. Therefore, consumers are misled by the popular idea

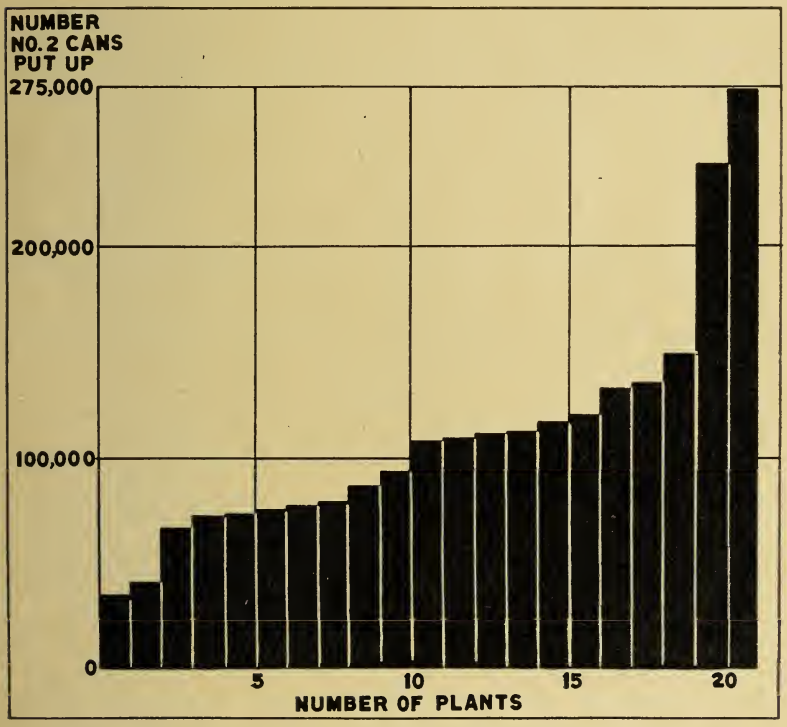


FIG. 3.—HOW PEA CANNING FACTORIES VARY IN SIZE.

The lengths of the black bars indicate the relative output per factory in number of cases of No. 2 cans. They ranged from less than 40,000 cases to almost 275,000 cases.

that the only justifiable element of cost in canned peas is the peas themselves. Manifestly, it injures the market if buyers consider the product worth only three cents simply because farmers received that amount. If consumers know that the finished product actually costs 10.21 cents—made up of many items of expense beside what farmers are paid,—this information tends to convince the consumer that he is not overcharged.

This knowledge leads to greater demand. Such information is helpful to farmers also because it explains some of the unknown facts about market outlets. Green peas could not be produced

TABLE III.—CANNING FACTORY TOTAL COSTS BY SIZES OF PLANT

Output in number of doz. of cans of No. 2 size	Number of factories	Average output per plant in doz. of No. 2 cans	Average factory cost per doz. No. 2 cans	Average general and selling cost per doz. No. 2 cans	Average total of all costs per doz. No. 2 cans
Under 60,000	2	37,874	$1.063	$.116	$1.179
60,000 to 80,000	6	74,162	1.144	.170	1.314
80,000 to 100,000	2	90,347	1.069	.168	1.237
100,000 to 120,000	5	112,056	.973	.215	1.188
120,000 to 140,000	3	126,759	1.053	.186	1.239
140,000 and over	3	220,849	1.065	.143	1.209
Average of 21 factories		110,186	1.055	.176	1 231

in present quantities were it not for the hermetically sealed can and for canning plants and machinery that minimize the expense of processing in large amounts.

MANY INFLUENCES AFFECT CANNING

Peas are canned in factories which vary greatly not only in size, but also in the ability and efficiency of their management. As a consequence, some factories put up and dispose of their products at much greater expense than do the more efficient concerns. Furthermore, the variation in yield and quality of green peas decidedly influences the cost and value of the annual pack. To view costs from any one angle to the exclusion of others equally important, is to invite injury to an industry in which Wisconsin farmers and canners have taken the leadership. Each angle of the industry must be viewed in the light of facts as they appear in practice.

SIZE OF FACTORY DEPENDS UPON ACREAGE AND YIELD

The cost of canning is apparently the same, whether canning factories are large or small, provided they are operated at capacity and are efficiently managed. Figures grouped according to sizes of plants (shown in Table III) indicate this clearly. The expediency of canning peas in large or small plants must, therefore, hinge largely upon the acreage of peas likely to be

grown annually during the life of the factory and its equipment. That 16 out of 21 factories were equipped as *two line*[3] plants, while the majority of the plants canned peas from acreages varying from 400 to 800 acres—averaging 644 acres—suggests an important relation. One reason why canning costs differ is because factories cannot be operated efficiently and at full capacity always. At times, new acreage may be added to utilize additional machinery fully and so a factory may be enlarged. However, after additional lines are installed any reduction in acreage necessarily means that one or more lines are likely not to be operated at full capacity. Hence in some cases, larger plants actually may have greater operating expense than smaller plants. It is important, therefore, that a canning factory should be adapted to efficient canning of the average annual yield of peas.

PEA CANNING FACTORIES EXPENSIVE

Pea canning is a costly undertaking because peas must be picked or hulled, cleaned, graded, placed in cans, and processed. These operations must be performed either by hand or by costly machinery. To save labor, as well as to guarantee that the work will be done, requires expensive machinery. But in spite of high expenditure for machinery the work is thereby done at less cost than by the use of hand labor. For example, viners now do the work which formerly required 200 women. No factory reported less than three viners and many plants had

TABLE IV.—AUTHORIZED AND PAID-UP CAPITAL OF PEA CANNERIES

Amount of capital authorized	Number of companies	Total authorized capital	Total paid-up capital	Average authorized capital	Average paid-up capital
$25,000 to $50,000	5	$180,000	$169,000	$36,000	$33,800
$50,000 to $75,000	4	222,800	212,600	55,700	52,520
$75,000 to $100,000	3	240,000	167,200	80,000	55,738
$100,000 to $125,000	5	520,000	482,500	104,000	96,500
$125,000 and over	2	700,000	485,900	350,000	242,950
Total	19	$1,862,800	$1,517,200	98,042	79,852

[3] The number of lines refers to the number of units of machinery installed for canning peas.

seven or eight. The average was 10 viners per factory. That would mean employing 2000 women to do only a fraction of the work which must be done before green peas are canned. Therefore labor as well as space is economized by utilizing machinery even though it is expensive. More important still, the machine guarantees that this work will be done for which laborers could not be secured in sufficient numbers.

Few persons realize that a pea canning factory calls for a paid-up investment varying anywhere from $100 to $200 or more per acre of peas grown. In Table IV both the authorized

FIG. 4.—ONE OF WISCONSIN'S PEA CANNING FACTORIES.
Plants of this kind represent on an average an investment of $125 for every acre of peas grown for canning.

and paid-up capital of 19 concerns are shown according to size groups. The average paid-up capital of almost $80,000 per plant, when compared to an average of 644 acres of peas grown and canned, indicates that pea canning factories cost $125 per acre of peas.

PEA CANNING IS INTRICATE PROCESS

Since the delicate, fresh flavor of canned peas makes them desired by consumers and because this quality is easily destroyed—either by delayed or careless harvesting, or by unskillful handling and processing in the canning factory—expert management is essential. The expense of employing expert management, combined with a heavy investment and the fact that the plant can be operated for a short time only and at great speed, make relatively heavy costs unavoidable. That boxes, cans and condi-

ments represent raw materials which cost far more than the green peas themselves further suggests that canning is a complicated form of manufacturing. The managers of canning concerns, therefore, whether they be employed by private or by cooperatively owned and operated companies, are obtainable only by paying good salaries and commissions. Necessarily, this contributes to a relatively large overhead expense.

Pea Canning Unusually Hazardous

The principal hazards of the pea industry are due to the extreme fluctuations in quantity and quality of green peas produced annually, and in the difficulty of properly processing the peas. The supply of green peas to be canned depends partly on the acreage and partly upon the yield per acre. While the acreage might be controlled, it is impossible to overcome weather conditions which cause high or low yield and good or poor quality—all of which so vitally affect the cost and value of the annual pack. Among the principal causes of low yield and poor quality are disease ravages, excessive rain, and shortage of moisture due to dry growing season.

Table V.—Fluctuation in Average Yield of Peas and Pack for Six Canning Plants

Year	Average number acres of peas	Average pounds of peas per acre	Average number cases of peas packed	Per cent changes in acreage compared to 1915	Per cent changes in yield compared to 1915	Per cent changes in pack compared to 1915	Per cent changes in net profit compared to 1915
1915....	663	2,114	75,531	100.0	100.0	100.0	100.0
1916....	682	1,967	65,242	102.8	93.0	86.4	78.4
1917....	719	1,956	74,983	108.4	92.5	99.3	109.8
1918....	789	2,448	101,896	119.0	115.8	134.9	98.0
1919....	848	1,709	77,153	127.7	80.8	102.1	51.0
Av. for 5 years	740	2,035	78,961	111.6	96.3	104.5	80.4

Some idea of the variations occurring in Wisconsin factories may be gained from data in Table V. These figures indicate that while the acreage of peas grown has steadily increased, the yield per acre fluctuated violently from 2,448 pounds per acre

to only 1,709 pounds. Moreover, while the very low yield of 1919 increased canning costs unduly and reduced profits to little more than one-half of what they had been in 1918 and 1915; profits in 1917 were the highest in spite of a low yield because a greater pack was fortunately obtained. An unusual demand also gave prices which were above normal and this increased profits greatly.

TABLE VI.—FLUCTUATION IN PRODUCTION OF CANNED PEAS

Year	Total cases of peas packed in United States	Cases of peas packed in Wisconsin	Per cent variation of U. S. supply based on average[1]	Per cent variation of Wis. supply based on average[2]	Per cent changes in Wis. output compared to 1908
1908.....	5,577,000	2,200,000	74.6	75.7	100.0
1909.....	5,028,000	1,878,000	67.2	64.7	85.3
1910.....	4,347,000	1,086,000	58.2	37.3	49.3
1911.....	4,532,000	1,520,000	60.6	52.3	69.9
1912.....	7,037,000	2,658,000	94.1	91.4	102.8
1913.....	8,770,000	3,348,000	117.3	115.1	152.8
1914.....	8,847,000	3,555,000	118.4	122.2	161.5
1915.....	9,272,000	3,469,000	124.7	119.3	157.6
1916.....	6,686,000	2,763,000	89.8	94.1	125.5
1917.....	9,829,000	3,569,000	131.5	122.7	162.2
1918.....	11,063,156	4,519,934	148.0	155.8	205.4
1919.....	8,685,000	4,317,000	116.2	148.5	196.2
Total 12 years.....	89,673,156	34,882,934	.....	.....	.....
Average 12 years.....	7,472,156	2,906,911	100.0	100.0	132.1

[1] Average pack in United States 1908 to 1919.
[2] Average pack in Wisconsin 1908 to 1919.

While Wisconsin produced one-half of the canned peas of the country in 1919, this leading position does not prevent fluctuation in the annual supply of peas as Table VI indicates. Less than half as many peas were canned in Wisconsin in 1910 as in 1908 and the country's total pack also dropped off seriously at the same time. This undoubtedly was due not to inability to grow the raw material but to the fact that consumers would not purchase such large quantities at remunerative prices. Consideration of the facts of the supply and demand for canned peas indicates that it is a most hazardous undertaking. Since

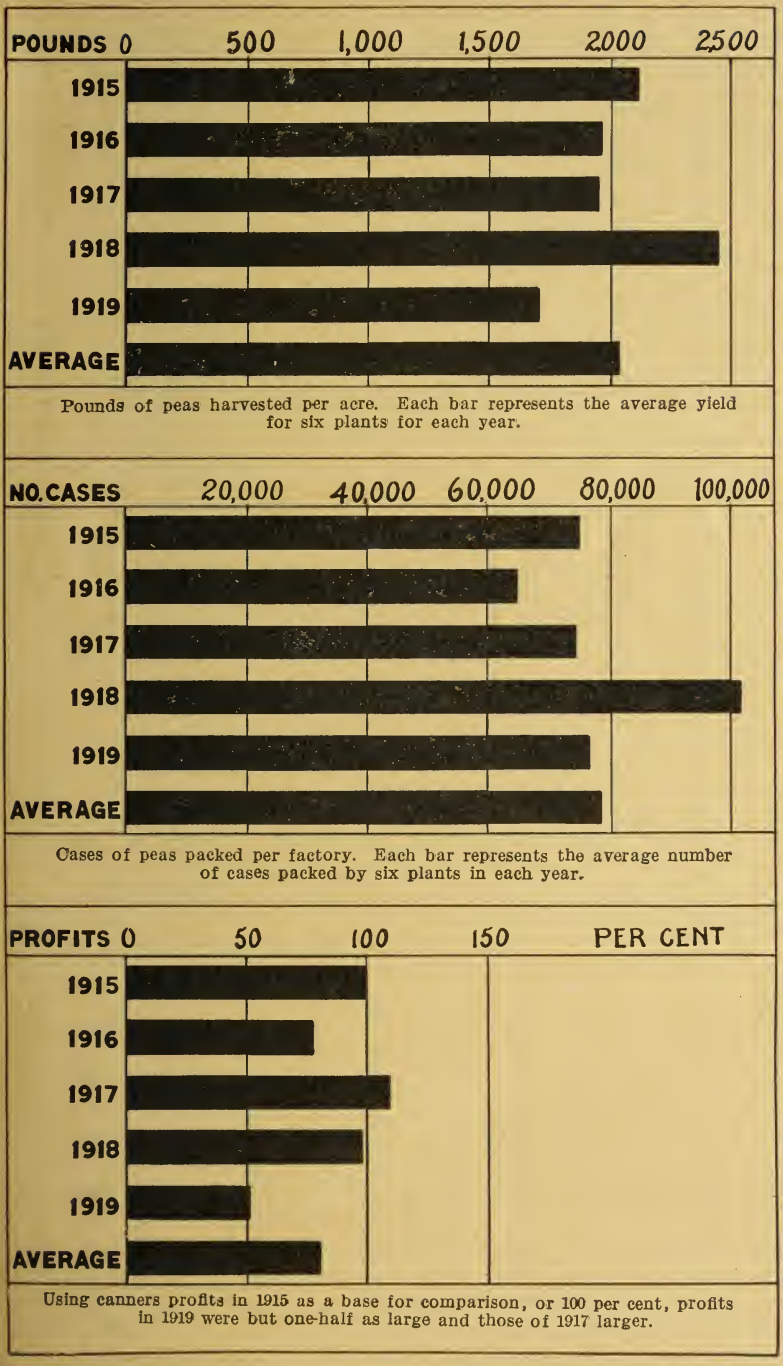


FIG. 5.—ANNUAL AVERAGE VARIATIONS FOR SIX FACTORIES.

neither yield, quality, nor demand are controllable or stable, the prospect of both remunerative prices and attractive profits is a matter of chance far more than in the case of farm commodities such as livestock, wheat, and dairy products, for which demand is more definite and constant.

COST OF CANNING PEAS

Pea canning costs vary from year to year as well as for different factories during the same year. The average costs for 1919, together with the highest and lowest expenses, are shown in Table VII. The differences in expenditure for any single item of expense as shown in this table are more than enough to

TABLE VII.—RANGE OF PEA CANNING FACTORY COSTS—1919[1]

Item of expense	Average cost per doz. cans	Highest cost per doz. cans	Lowest cost per doz. cans
	Cents	Cents	Cents
Green peas[2]	36.52	42.10	26.80
Cans	31.37	35.70	28.40
Direct labor	12.02	21.72	6.45
Factory overhead	11.87	24.10	5.81
Boxes	7.23	9.00	4.70
Depreciation[3]	3.61	6.90	1.64
Labels	1.99	3.15	.90
Condiments	1.60	3.12	.50
Interest on borrowings[4]	1.55	3.19	.05
General overhead	7.81	20.80	3.06
Selling expense	6.98	10.40	4.10
Total cost	122.55	140.70	106.00
Net profit[5]	15.91	.....	.....
Selling price	138.46	.....	.....

[1] Compiled from data submitted by 22 Wisconsin pea canning plants for 1919.
[2] The extreme variation in cost of green peas is due to a number of conditions chief of which are (1) the higher price paid for highest grade peas and the low price paid for poor peas, (2) the fact that some companies grew large acreages of peas which were charged up at lower prices than were paid to farmers or visa versa.
[3] Depreciation on building and machinery.
[4] Money required for short time to finance canning operation.
[5] Net profit before deduction of income taxes.

mean profit or loss for any company. The fact that a concern paying a high price for cans paid a lower price for peas, or operated with less overhead or with other smaller expense, en-

abled it to keep the total costs at a figure varying from $1.06 to $1.41 per dozen cans, which sold for an average price of $1.38½ per dozen. That the average cost was $1.22½ while the average price was $1.38½ resulted in profits for the canners averaging 15.9 cents per dozen cans.

WHAT BECOMES OF THE CANNING FACTORY'S DOLLAR

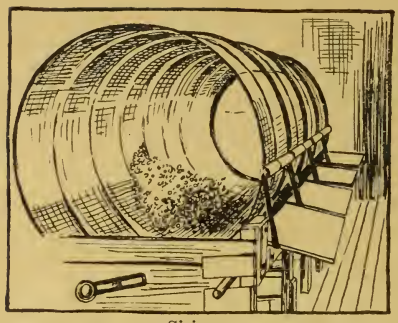
Few persons realize that pea canning is such an intricate and expensive process. Table VIII shows the average cost of producing a finished can of No. 2 size. In this size of can are contained about 14 ounces of peas and 7 ounces of liquor. This 14

TABLE VIII.--FACTORY COSTS ON 30, 138, 336 CANS OF PEAS NO. 2 SIZE[1]

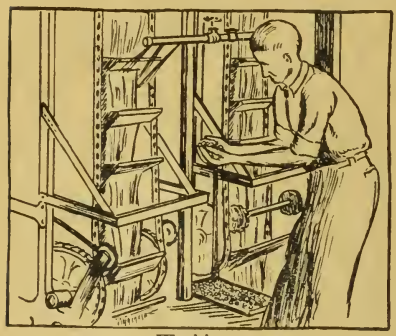
Item of expense	Average cost per No. 2 can	Per cent of total cost	Per cent of selling price
	Cents		
Green peas	3.04	29.8	26.4
Cans	2.62	25.6	22.7
Direct labor	1.00	9.9	8.7
Factory overhead	.99	9.8	8.6
Boxes	.60	5.9	5.2
Depreciation[2]	.30	2.9	2.6
Labels	.17	1.6	1.5
Condiments	.13	1.2	1.1
Interest on borrowings[3]	.13	1.2	1.1
General overhead	.65	6.4	5.6
Selling expense	.58	5.7	5.0
Total cost	10.21	100.0	.....
Net profit[4]	1.32	.....	11.5
Selling price	11.53	.....	100.0

[1] Compiled from facts submitted by 22 Wisconsin pea canning plants.
[2] Depreciation on buildings and machinery.
[3] Pea canners are obliged to borrow money to finance their purchase of peas, supplies, and various other expenditures during the flush producing season before money is recovered for the finished product.
[4] Net profit before income taxes are deducted.

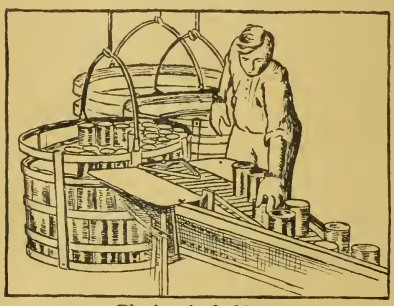
ounces of green peas cost factories on an average 3.05 cents or 29.8 per cent of their total costs. The expenditure for cans amounted to almost as much as that for the peas, while cans and boxes combined actually cost 3.22 cents or more than the peas. More than three-fifths of the cost of canning peas or 61.3 per



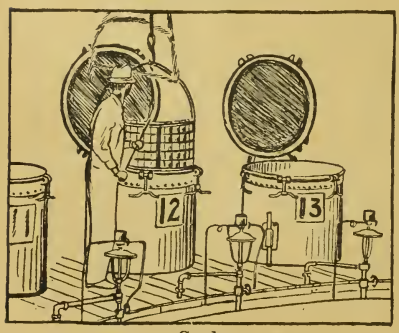
Sizing.



Washing.



Placing in holder.



Cookers.

FIG. 6.—A FEW STEPS IN CANNING PEAS.

cent, therefore, represented raw material and containers. The remaining expenses amounting to 3.94 cents or 38.7 per cent of the total cost as shown in Table VIII, were for operating and maintaining the factories including warehouse facilities, management, and selling arrangements.

As a result of consumer demand and the various costs of distributing peas, canning factories received an average price of 11.53 cents per No. 2 can of peas. Since the total cost amounted to 10.21 cents per can, company profits averaged 1.32 cents on each can. It should be emphasized that the profit as herein referred to means only the amount of profit per can of peas. It has no direct reference to rate of profit earned on capital stock. Furthermore, various items such as income taxes were not deducted from net profit as here shown because they were so variable.

It should be emphasized in any comparison of the profits of pea canning companies with profits of other enterprises that the money invested is turned over but once during a year. In this respect, pea canning concerns are confronted with problems

similar to those met by farmers. With both farmers and pea canning factories, losses cannot be overcome so readily as in other work where the turnover varies from five to thirty times annually. The further fact that canning plants must stand idle from 40 to 48 weeks out of the year because peas are canned only during a period of 4 to 8 weeks, inevitably means a heavy risk that justifies commensurate pay. Middlemen and producers whose turnover is rapid are more able to make up for any losses during the same year than are those with only one turnover. Obviously the margin of profit tends to be wider in cases of slow turnover than in instances where turnover is rapid. Competition leads to this situation. Were the profit narrower, money would be invested in other industries than pea canning and neither farmers nor consumers would be benefited by markets and supplies.

To the consumer who enjoys eating peas it must be a consolation to know that factory costs per can actually approximate 10.21 cents even though the green peas cost only 3.05 cents. Similarly, the farmer must appreciate that these various basic costs must be met in some way or other. That cooperative pea canning factories had to meet all the same expenses as the private factories studied, is doubly reassuring to both consumers and farmers. Furthermore, that the price of green peas increased 61.5 per cent while the factory value of the pack increased 46.2 in the face of costs that rose 79.4 per cent during a five-year period, means that conditions in the industry are flexible and that various adjustments are being worked out within it. It is to the vital interest of both farmers and canning companies to have markets which will demand peas at prices on a new level which will be remunerative alike to farmers, to can and box manufacturers and to canning companies. Information which assures consumers that farmers and factories are doing their utmost to improve the quality and to turn out greater quantities and larger proportions of high grade produce will increase demand. Moreover, if consumers become convinced that canned peas justify high prices, because the processes of growing and canning them are expensive, they will willingly pay adequate prices for what they want rather than go without their accustomed supply. Future progress of the Wisconsin pea canning industry will be guaranteed by tempering the various

individual interests to a program which emphasizes giving the consumer quality and knowledge of costs. and of providing both farmers and canners with an equitable division of the value of their product based on average results over a period of years rather than for short periods of time.

Canning Enlarges Markets

Canning highly perishable products is a boon both to consumers and to farmers. Consumers now enjoy preserved fruits and vegetables throughout the year largely because of it. By preserving perishable products for sale throughout twelve months, compared to former markets restricted to a few weeks or months, canning enables farmers profitably to produce perishables in a vastly greater quantity. Canning is therefore a necessary marketing service.

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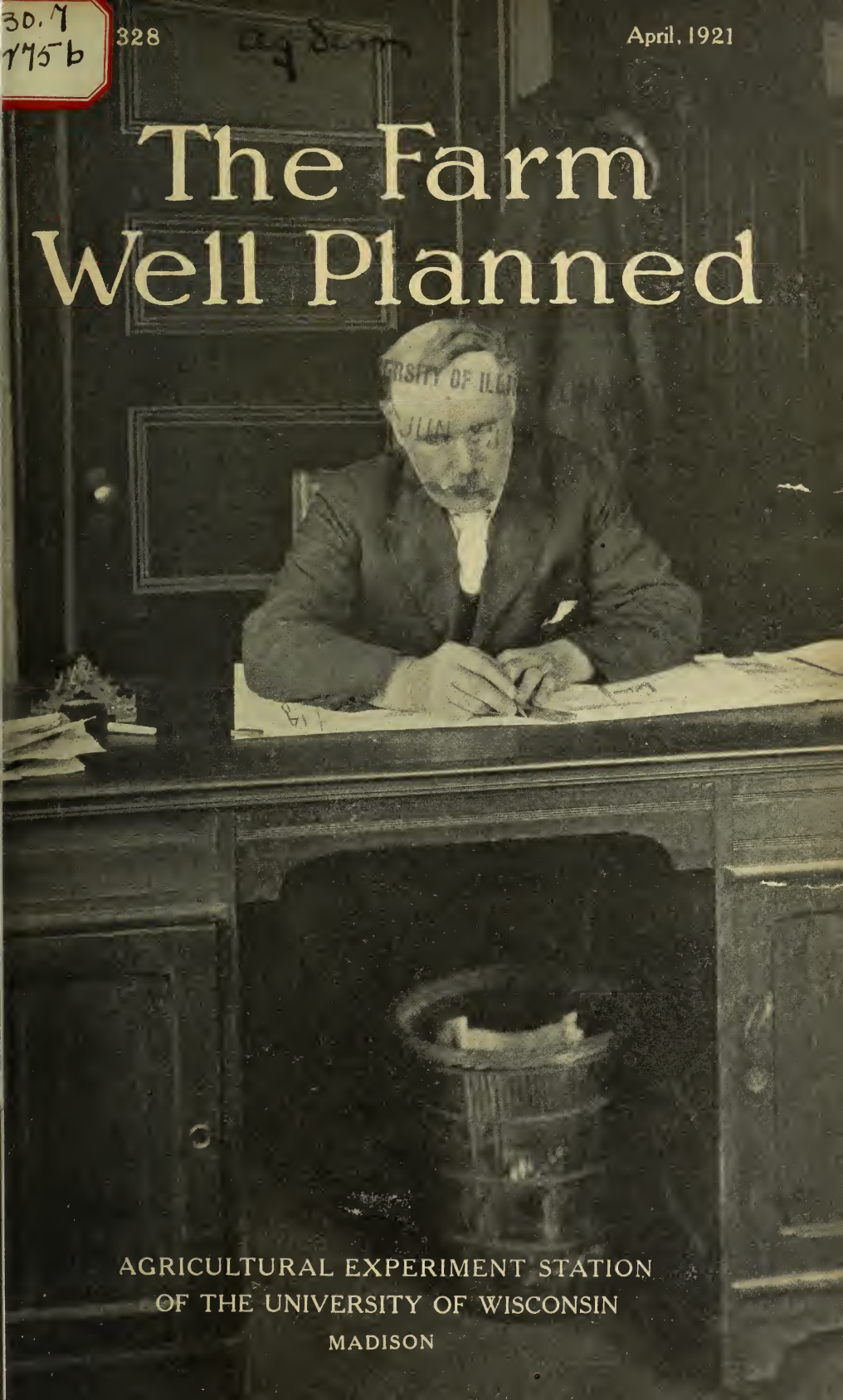
April, 1921

The Farm Well Planned



AGRICULTURAL EXPERIMENT STATION
OF THE UNIVERSITY OF WISCONSIN
MADISON

DIGEST

Crops for basic rotation in Wisconsin are corn, small grains and hay. The acreage of each crop is readily adjusted in any rotation system to meet the needs of the farm. Page 5

Large fields are desirable. They reduce the expense of fencing and cultivating and also permit the use of tractors. Pages 7–8

Fields should be regular. It is desirable to have fields one-half longer than they are wide. Plowing, planting, cultivating, and harvesting are more economically handled with long rows. Page 8

The entrance to fields should be near the buildings whenever possible. This saves time in going to and from work. Page 8

Fields should be worked at right angles to the natural slope. This means that it is necessary to study the slope of the fields carefully in making a revised farm plan. Page 8

Steps in farm planning are: Determining the number of cultivated acres; locating the hog pasture near the barn; placing the fields in the pasture rotation so that they will be readily accessible from the barnyard. Page 10

A rotation schedule is needed to show what crop goes into each field yearly. It is helpful to have these crops numbered. Pages 10–11

The rotation schedule can be readily adjusted to meet changing conditions. Substitute crops may be used so as to permit following out the schedule. Page 12

A study of typical farms aids one in replanning his own. Original and revised plans of average farms offer interesting comparisons. Pages 14–28

The Farm Well Planned

D. H. Otis*

The field plans of Wisconsin farms today are the result of a gradual process of fitting the changing needs of a developing agriculture to local conditions. Because they are the product of haphazard growth rather than of definite planning these arrangements are often inefficient.

Replanning them for the purpose of saving labor, maintaining fertility, and increasing production is therefore worth while. The principles of effective field lay-out are not difficult to follow as the actual examples of successfully replanned farms indicate.

How Farm Plans Developed

Wisconsin farms have developed slowly. Fields have been cleared a little at a time. Additions have been made by purchase, or parcels have been sold off. The one-crop system of sixty years ago has been altered by the addition of other crops from time to time increasing the number of fields. Crop rotation has arisen naturally from the need for using different pieces of land for the cultivated crops, small grains, and meadows in order to give the land in cultivated crops a rest. This means to *maintain fertility*, or productive power, as well as to combat more successfully the increasing numbers of noxious weeds and insect pests.

As the type of farming in each region has become more stable, field plans filling the general needs of each type have been worked out. In these systems original field lines have been rather closely followed because crops were rotated on the basis of what each particular crop required rather than on the basis of the farm as a whole. As new acres were broken up for cul-

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* S. W. Mendum, of the Department of Agricultural Economics, assisted in preparing the manuscript for publication.

tivation they were usually handled as field units, each with a different crop each year. Therefore, as the farm developed it had many separate fields, each with the same crop—three or four lots of corn, and others of hay and small grains—until it looked like a patch-work quilt.

Small irregular fields require more labor than do large regular fields; they require more fence when livestock is kept; there is more waste around the edges, to say nothing of the land used for lanes or wagon tracks; and the time spent going to and from fields is often considerable.

CHOICE OF CROPS

Experience has probably led to the adoption of the type of farming best suited to the region in which the farm is located. The farmer knows what crops can be grown successfully on his land, how they are affected by soil and climate and what crops are usually most profitable under ordinary market conditions. He practices rotation in a general way by changing fields occasionally. If he has livestock, he plans his crops to provide for their needs either with or without buying additional concentrates or roughage. Experience has also shown in a general way how much of each crop he can grow with his available labor without changing the size of the farm. Since the general farm scheme is usually well settled, the principles of choice of type of farming need not be discussed, but rather the replanning of the farm to increase the effectiveness of the type adopted.

RELATION OF CROPS TO LIVESTOCK

Adjusting the kinds and quantities of crops to support the livestock is important. Crop production in itself does not need to be discussed here. The types and amounts of crops produced are more or less dependent on circumstances but may be varied, within reasonable limits depending upon weather conditions, almost at will in any season. While the following principles will guide in planning for straight cash crop production, the needs of livestock farmers are most prominent.

From the size of the farm, the crops most successful on it and their average yields, the amount and type of livestock to be kept

is estimated. Enough stock should be kept to consume the feed that can be grown. This is, of course, subject to many variations. If the farm is overstocked, feed must be purchased—usually the concentrates. If it is not stocked to capacity some grain or hay may be sold. The feeding plans determine the rotation to be followed and the farm layout depends on the rotation.

BASIC ROTATIONS

Rotation systems for Wisconsin livestock farms are planned on corn, small grains, and clover or alfalfa, with or without pasture. The "clover" or simplest rotation is corn, oats, and clover in three fields of equal size. Corn is followed by oats or other small grain seeded to clover. This is cut for hay the third year and the clover sod is turned under for corn again the next year, repeating the order. If pasture is needed, the rotation is lengthened one year and four fields are used instead of three, timothy being seeded with the clover and held over a year.

Because of the greater expense of establishing alfalfa and on account of its persistency, rotations including it are usually planned for five or more years with a like number of fields. To distinguish it from others based on clover hay, it is called the "alfalfa" rotation. All the rotations mentioned in this bulletin are modifications of these two. They are given below together with a rotation adapted to the special needs of hogs.

TABLE 1.—BASIC ROTATIONS

"Clover" Rotation		"Alfalfa" Rotation		Hog Pasture Rotation	
Crop No.	Crop	Crop No.	Crop	Crop. No.	Crop
(1)	Clover and timothy (hay)	(1)	Alfalfa	(1)	Clover pasture
(2)	Pasture	(2)	Alfalfa	(2)	Corn
(3)	Corn	(3)	Alfalfa	(3)	Oats, peas, or rape
(4)	Grain seeded to clover and timothy	(4)	Corn	(4)	Grain seeded to clover
		(5)	Grain seeded to alfalfa		

THE CLOVER ROTATION

The clover rotation given is a four-year one providing pasture. In it timothy is seeded with the clover in the small grains. If there is plenty of pasture on the farm without this, the pasture field may be cut for hay (largely timothy) for horses, or the rotation may be reduced to three years. In this case three fields are used instead of four and the timothy is omitted in seeding down. If more corn is needed, it may replace pasture. If both pasture and more corn are needed the number of fields may be increased to five and corn put in two fields. Any other annual crop may be substituted for corn in whole or in part on the "corn" field.

THE ALFALFA ROTATION

The usual life of alfalfa where successful in Wisconsin is three or four years before it winter kills or is choked out by blue grass. The five year rotation shown provides for alfalfa on the same field three years before being plowed under for corn. If alfalfa lasts longer with a good stand it may be desirable to increase the rotation to six or more years. If more corn were needed this would also be true, even with alfalfa retained only three years. If three fields are needed for corn the rotation may be increased to seven years, one-third of the alfalfa being turned under each year for corn. Sometimes bluegrass or noxious weeds cannot be subdued in the one year devoted to a cultivated crop in the five year alfalfa rotation. In that case it may be desirable to increase the rotation to six years using two cultivated crops in succession. Either or both of these rotations, clover and alfalfa, may be used on the same farm at the same time.

THE HOG PASTURE ROTATION

A large variety of crops may be used for hog pasture. Alfalfa is sometimes used instead of clover, and when it grows luxuriantly it may constitute the sole forage crop for hogs. It furnishes good, nutritious pasture from early spring to late fall. It is desirable, however, to have several small fields and to shift from one to another to prevent too rapid killing out of the plants.

Corn is a good crop to "hog down." Temporary fences may be run across the fields and moved from time to time forcing the hogs to clean up as they go, thus reducing waste. The period during which corn can be utilized may be extended by using different varieties of corn or by planting at intervals. Oats, peas, and rape may be planted together or separately. Other grain crops may be used. Succotash is the name of a mixture of small grains grown together. Where many hogs are kept, the rotation may be profitably enlarged to five or six fields requiring a like number of years to complete the rotation. The fields for this should usually be close to the barns. Hog pastures yielding more feed than is needed for the hogs may be pastured with other stock or a portion may be set off with a temporary fence and harvested.

Size of Fields

The fields should be as large as possible. Size is sometimes limited by natural or other characteristics of the farm; a highway, railroad, brook, ledge, slough, or wood lot may interfere. Otherwise the rotation or rotations adopted determine the size of fields as indicated above. The principle is to divide the farm into as many equal fields as the rotation runs in years. But, as stated above, the number of years a rotation runs is somewhat governed by the quantity of corn or of hay needed. A simple three year rotation indicates that the total tillable land be worked as three fields, a five-year rotation as five fields. On the same farm, therefore, the individual fields will be smaller with a five-year rotation in effect than with a three or a four-year rotation. A farm with a hundred acres under cultivation would have for a three-year rotation 33 acres each of corn, small grains, and clover. The same farm with a four-year rotation providing additional corn would have four 25-acre fields, of which two, or 50 acres, would be corn. Under the basic five-year alfalfa rotation there would be five fields of 20 acres, 20 acres of corn, 20 of small grains and 60 acres of alfalfa. If more corn were desired and the six-year rotation adopted, there would be 33 acres of corn, 17 of small grains and 50 of alfalfa. Other modifications of acreage used for each crop may be effected by combining an alfalfa and a clover rotation in various proportions.

Large fields materially reduce the expense of fencing. The use of the tractor makes large fields desirable. In cases where the soil of a field is not uniform, and cannot well be given the same treatment throughout, it may be necessary to leave the field divided. Tile drains may be used to render such a field capable of uniform treatment when the chief trouble is too much water.

SHAPE OF FIELDS

Irregular fields are difficult to work. They should, therefore, be laid out as nearly rectangular as possible. In plowing, planting, cultivating and harvesting it is decidedly better to have long rows or strips than short ones. Fields one-half longer than wide are desirable when they can be arranged. The shape of a field may often be much improved by drainage, or by clearing away rocks or stumps along edges or in corners.

LOCATION OF FIELDS

Considerable time and some land will be saved if the fields are laid out so as to be easily reached, with the entrance as near the buildings as possible. This is particularly true where pasture is a part of the rotation plan. Where the public highway divides the farm, two or more rotations may be desirable. The one including pasture should be located on the same side of the road as the barns, where possible. The revised plans following show how these objects are attained as compared with the original time-consuming plans.

Some consideration will usually be given to the location of fields from the viewpoint of their influence on the appearance of the farmstead and the comfort and convenience of the family. The orchard and garden are usually located near the house. Hog lots should be removed from house, dairy, and public highway. The farm woodlot is usually a fixture, sometimes in an inconvenient position, but a well-kept grove near the house is attractive.

SLOPE OF FIELDS

Where the slope of any part of the farm is such that serious soil erosion may occur, the fields should be arranged so that

they may be worked at right angles to the natural wash of the soil. This is important and may necessitate a totally different arrangement from what might otherwise be desirable.

Miscellaneous Considerations

The availability and character of the water supply should be considered in locating buildings, yards and pastures.

Fences should not be used unless necessary as they are expensive, untidy, and useless except for pasture purposes.

Farms frequently have considerable waste or non-productive land. A plan should include consideration of possible uses to which this land may be put. The removal of stumps or rocks, the drainage of swamps, or the putting-in of a tile-head in a pocket or a low spot may make it easy to straighten some of the irregular fields, economize in labor and add to the productiveness of the farm.

It is well to draw a map in replanning to show the size and arrangement of the fields as they are wanted eventually whether the plan will be realized one or five years hence. The plan should be definite and every move made in accordance with it. There are, of course, factors which may delay its realization. Stumps may be in the process of rotting; land may need to be cleared of timber; or stones and old fences may need to be removed and new fences built. Even with cleared, cultivated land the crop of the year before may affect the plan. A good stand of clover or alfalfa should not be plowed under simply because it is located on land where the rotation normally calls for a different crop that year. The rotation must be adjusted to the crop conditions on the farm at the time the new plan is started. This is readily done as the rotation schedules following indicate. (See pages 15–17).

Pasture in rotation is more expensive than permanent pasture but it is more productive. It is also a means of adjusting the labor requirements on the farm. When there is plenty of help, more feed will be available if all the fields are worked. When labor is scarce a fair amount of feed can be provided through use of more meadow land, part of it harvested by the cows themselves.

Where the farm does not make enough stable manure to maintain fertility, the manure may be used on the fields near the

barn, the more distant being maintained by plowing under green manure (legumes) together with rock phosphate, lime or other elements as needed.

STEPS IN PLANNING THE ROTATION

The layout of the farm depends on the rotation to be followed. The aim is to provide one or more rotations that will furnish the needed feed, including pasture, and maintain fertility. This rotation should be adjusted to lend itself to economy in the amount and distribution of labor on the farm. In arranging for the lay-out of the fields the first step is to find the number of cultivated acres on the farm. If a hog pasture is to be provided, acreage sufficient for a hog rotation is set aside and located if possible within easy access to the hog barns and yards. The remaining cultivated acres are then divided for field purposes, according to the rotation or rotations desired. If 125 acres are available for this purpose, and it is desired to have one field, say 25 acres, set aside for alfalfa or other special crops, and the balance put into a four-year rotation with clover and timothy as the hay and pasture crop it will require five fields. In this case the available acreage is divided into five fields of 25 acres each. The fields in any one rotation are arranged to be as nearly the same size as possible, and where feasible made to join each other. Effort is made to locate each rotation where it will best serve the interests of the farm. If pasture is provided in rotation it will usually be with the rotation containing clover which means that this rotation should, where possible, be located within easy access of the barnyards or permanent pasture lot.

THE ROTATION SCHEDULE

In connection with the revised plan of the farm it is convenient to have a schedule for each rotation showing just which crop goes into each field each year. These should be made out separately and kept with the maps. In the schedule each crop is given a number according to its order in the rotation. A good way is to number or letter the fields and below these to arrange the crops to be used on that field. In the suggestions

below, substitute crops are designated by letters. These are crops used out of order in the rotation during the transition period. They are often necessary before the new rotations are established as planned or because of the failure of seedings. The starting point of a rotation schedule is usually a field that was seeded down the preceding year.

MAKING ROTATION SCHEDULES MEET CONDITIONS

Winter killing of clover and alfalfa will interfere seriously with the operation of any rotation schedule; and some farmers assert they cannot adopt a rotation on this account. When a seeding fails to "catch," or winterkills, a little careful planning will enable one to make such substitution as will prepare the field for the next crop in the rotation. In the rotation plans in this bulletin, alfalfa and clover are used frequently. If alfalfa winterkills one year before the schedule time for breaking up, a crop of oats and peas or any other annual crop may be used that year after which the field will fall into the regular rotation. If alfalfa kills out two years ahead of time, grain seeded to clover may be substituted the first year to be followed by clover hay the second, after which the clover sod should be plowed up and the field planted to corn. Where preferred, two annual crops may be grown instead. If alfalfa kills out earlier than this, the field can be seeded back to alfalfa or a crop of grain seeded to clover and timothy can be substituted. This will run two years after seeding.

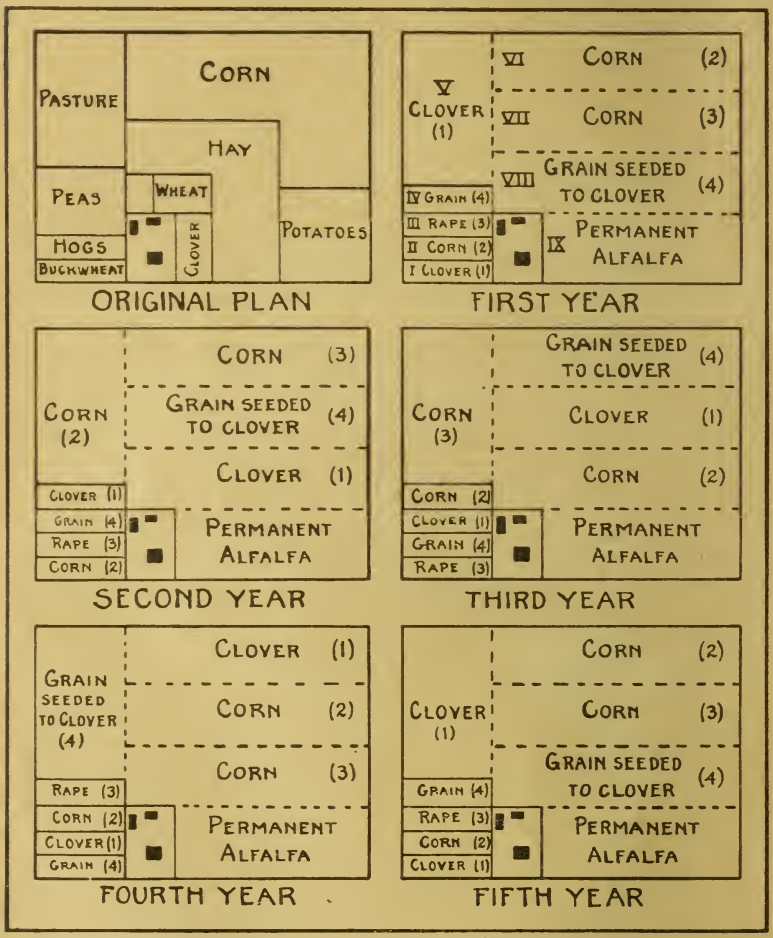
If clover kills out, an annual crop may be substituted. In substituting for alfalfa or clover it is usually desirable to select a crop that will furnish hay as nearly as possible of the quality of that lost to the farm by the winter-killing. Oats and peas serve this purpose well in Wisconsin. Soybeans may also be used with advantage.

When pasture kills out, succotash—a mixture of two or more spring grains—may take its place.

Alfalfa and sometimes red clover may kill out in low or wet places in the field. Where this occurs, alsike clover may be substituted.

When a farm is not fully stocked, or if the land needs special treatment in the way of inoculation or liming, or if the farmer

needs to acquire skill and experience in handling unfamiliar crops, substitutes may be desirable. These should be selected and adjusted to be out of the way when the time comes for the



PLAN SHOWING HOW ROTATION OF CROPS WORKS OVER A PERIOD OF FIVE YEARS

regular crop called for in the rotation plan and for which the soil is in suitable condition.

Noxious weeds like quack grass and Canada thistles may interfere with the seeding down of a field. Then it may be de-

sirable to substitute cultivated crops until such weeds are eradicated. Fortunately, a good stand of alfalfa will kill out many weeds, including Canada thistles.

Alfalfa and clover are usually seeded with some grain as a nurse crop. This utilizes the land and materially checks the weeds. On clean land it is possible to seed alfalfa without a nurse crop and, if the season is favorable, to obtain one crop of hay the same year. It is also possible to seed without a nurse crop in June and July. Some farmers are very successful in growing a crop of peas and then seeding down to alfalfa.

The grain used for the nurse crop varies according to the needs of the farmer. Barley, perhaps, is most frequently used. Oats probably come second and occasionally a seeding is obtained with peas. Good stands of clover and timothy are obtained by seeding timothy with rye in the fall and seeding the clover on the same field in the spring. With all nurse crops, care needs to be taken not to have them too heavy so as to smother the new seeding, or to sap unduly the moisture needed by young clover or alfalfa.

TYPICAL FARMS REPLANNED

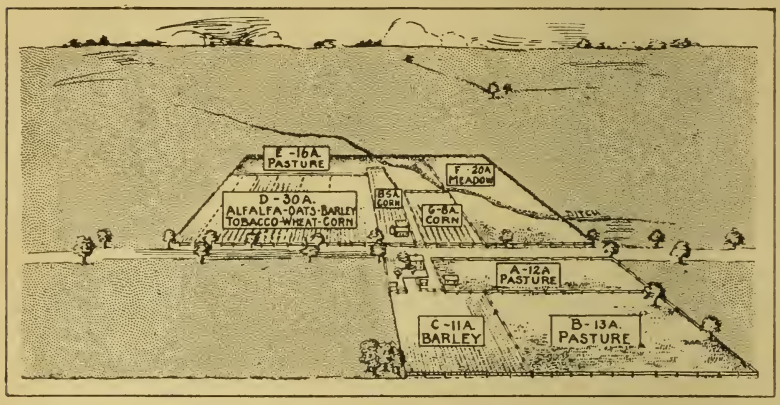
The principles of planning or replanning a farm layout and adjusting this plan to a systematic cropping system may be illustrated by taking an actual farm and showing step by step the process by which these principles are applied.

FARM NO. 1.—Total acres, 120; 2 miles from railroad station; type of soil, clay loam (Burr oak prairie); topography, rolling; 16 acres of permanent pasture and woods, 98 acres available for cultivated crops.

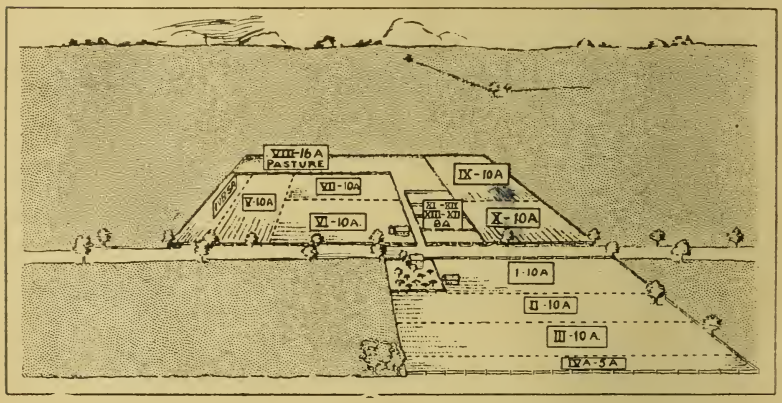
In the original map the fields are designated by letters starting with the letter A at the residence and proceeding around the farm clockwise. In the revised map the fields are marked with Roman numerals.

On this farm the land is well drained. Fields A, B, and C have sufficient slope to necessitate cultivation north and south to prevent soil erosion. There is a ditch through Fields E and F, leaving a shallow run which must be kept in grass to carry off the surface water after heavy rains. The residence, chicken houses, and a shed designed for curing tobacco are on one side of the road and the barns on the other.

The farm has been badly run down from renting. The owner is trying to build it up and to get started in the dairy business, gradually working into purebred dairy cattle. He desires to sell market cream and eventually to go into market milk pro-



FARM NO. 1.—ORIGINAL PLAN



FARM NO. 1.—REVISED PLAN

duction. He wants to raise all the roughage and in addition as much grain as he can. With his cropping system, he desires to use purebred seeds for the purpose of securing the largest production, and when market conditions are right to sell seeds and buy feed. He also desires to raise a considerable number of hogs, and for this purpose intends to keep from 10 to 15 brood sows.

In revising the farm plan, provision is first made for the hog pasture, since these fields should be near the barn. The next consideration is the rotation providing pasture for the dairy herd. The owner desires to have both clover and alfalfa as leading hay crops.

Fortunately, the land best suited to alfalfa is located in the west "forty," as is the residence. This makes it possible to locate the rotation containing clover (including pasture) on one side of the road, so that any field in this rotation is readily accessible.

Before drawing the revised map of the farm it is necessary to select the number and character of the rotations so as to determine the number of fields needed for the cropping systems.

After a conference with the owner of this farm it was decided that for his particular needs it was best to provide a four-year rotation for hog pasture, a four-year rotation with clover and a five-year rotation with alfalfa.

In this revised map it will be seen that eight acres (Fields XI, XII, XIII and XIV) have been set aside for the hog pasture rotation; 40 acres (Fields VI, VII, IX and X) are set aside for the rotation containing clover and pasture for the dairy herd; and 50 acres (Fields I, II, III, IV-A, IV-B and V) for the alfalfa rotation.

Having decided upon the number and character of the rotations needed for the farm, the next step is to make out a "Rotation Schedule" for each, showing what crop is to be planted in each field yearly.

FARM NO. 1—ROTATION SCHEDULE 1—HOG PASTURE*

Year	Field XI (2 acres)	Field XII (2 acres)	Field XIII (2 acres)	Field XIV (2 acres)
1st 192..	(2) Corn	(3) Oats, peas and rape	(4) Grain seeded to clover	(A) Barley
2nd 192..	(3) Oats, peas and rape	(4) Grain seeded to clover	(1) Clover	(2) Corn
3rd 192..	(4) Grain seeded to clover	(1) Clover	(2) Corn	(3) Oats, peas and rape
4th 192..	(1) Clover	(2) Corn	(3) Oats, peas and rape	(4) Grain seeded to clover

* When a seeding fails or winterkills see "Making Rotation Schedules Meet Conditions." Page 11.

In starting a rotation schedule it is usual to start with a field already seeded down to clover. In the hog pasture rotation there was no field seeded the preceding year, so it was deemed wise to start with Field XIII which was in the best condition for seeding. Starting this field with crop No. (4) it was then an easy matter to assign the other fields their appropriate crops and proceed systematically with the schedule.

Barley is used as a substitute crop for Field XIV, which would normally be in clover. Any other annual crop could be used instead of barley without interfering with the plan of the rotation.

FARM NO. 1—ROTATION SCHEDULE II—ROTATION WITH CLOVER*

Year	Field VI (10 acres)	Field VII (10 acres)	Field IX (10 acres)	Field X (10 acres)
1st 192..	(4) Grain seeded to clover and timothy	(A) Oats and peas	(B) Pasture 3 a. Corn 7 a.	(3) Corn
2nd 192..	(1) Clover and timothy meadow	(B) Oats and peas	(3) Corn	(4) Grain seeded to clover and timothy.
3rd 192..	(2) Clover and timothy pasture	(3) Corn	(4) Grain seeded to clover and timothy	(1) Clover and timothy meadow
4th 192..	(3) Corn	(4) Grain seeded to clover and timothy	(1) Clover and timothy meadow	(2) Clover and timothy pasture

* What to substitute when a seeding fails or winterkills see "Making Rotation Schedules Meet Conditions." Page 11.

Field IX (rotation with clover) contained 3 acres of pasture left from a previous seeding. In order to preserve what little seeding there is available, the rotation schedule was started with this field. In deciding on the substitute for Field VII it was thought wise to grow oats and peas, cut for hay, since the farm was decidedly short of hay. After the second year the schedule adjusted itself to the regular rotation.

The schedule for the alfalfa rotation is made on the assumption that it is possible to prepare one field a year for seeding to alfalfa. If this is not possible, it is easy to substitute a rotation with clover in three or four of the fields. Alfalfa can then be tried in one field, or even a portion of a field, until conditions justify a larger acreage.

FARM NO. 1—ROTATION SCHEDULE III—ROTATION WITH ALFALFA*

Year	Field I (10 acres)	Field II (10 acres)	Field III (10 acres)	Field IV-A and IV-B (10 acres)	Field V (10 acres)
1st 192-	(A) Corn 5a. Tobacco 5a.	(B) Corn	(C) Oats and peas	(4) Corn	(5) Grain seeded to alfalfa
2nd 192-	(B) Corn 6½a. Potatoes 2a. Tobacco 1½a.	(C) Oats and peas	(4) Corn	(5) Grain seeded to alfalfa	(1) Alfalfa
3rd 192-	(C) Oats and peas	(4) Corn	(5) Grain seeded to alfalfa	(1) Alfalfa	(2) Alfalfa
4th 192-	(4) Corn	(5) Grain seeded to alfalfa	(1) Alfalfa	(2) Alfalfa	(3) Alfalfa
5th 192-	(5) Grain seeded to alfalfa	(1) Alfalfa	(2) Alfalfa	(3) Alfalfa	(4) Corn

*What to substitute when a seeding fails or winter kills see "Making Rotation Schedules leet Conditions." Page 11.

This farmer desired to grow tobacco for a few years as a cash crop. Provision is made for this in the substitute crops.

It will be noticed that Field III requires one year, Field II, two years, and Field 1, three years, before they are ready for the regular rotation. Should it be necessary to substitute some clover until alfalfa has shown its adaptability to the farm, a considerably longer time would be needed to make the transition. The farmer, however, has a definite plan before him and adjusts his operations to that plan.

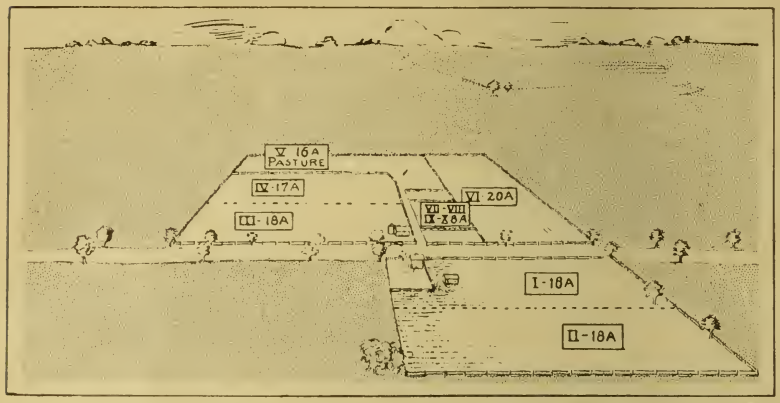
Objections to the plan. The plan given for Farm No. I makes the fields rather small, ten acres each. This would be particularly objectionable if a tractor were being used. Again, Field IV is separated into two parts, A and B, which is objectionable, but unavoidable. In the rotation containing alfalfa, however, there will be no fences, and for many farm operations two or more fields can be grouped together and handled as though they were in one large field.

ANOTHER REVISED PLAN OF FARM NO. 1

The second revised plan of Farm No. 1 provides for larger fields by dividing the cultivated land, other than pasture for hogs, into five fields of about 18 acres each.

One of these fields can be set aside for alfalfa, the remaining four fields can be devoted to a four year rotation with clover

and timothy as a hay crop. The rotation would be essentially the same as provided in Schedule II, except that in this second revised plan pasture in rotation would probably be omitted and



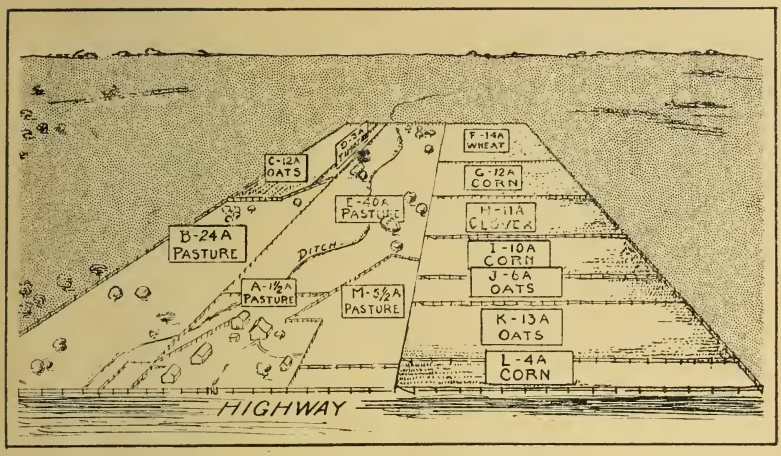
FARM NO. 1.—ANOTHER REVISED PLAN WHICH MAKES PROVISION FOR LARGER FIELDS

a second year hay crop obtained instead. The adoption of this plan will call for the extensive use of the summer silo, or for a liberal allowance of soiling crops. It will permit the keeping of a larger number of cattle, however, and will make possible dividing the farm into larger fields.

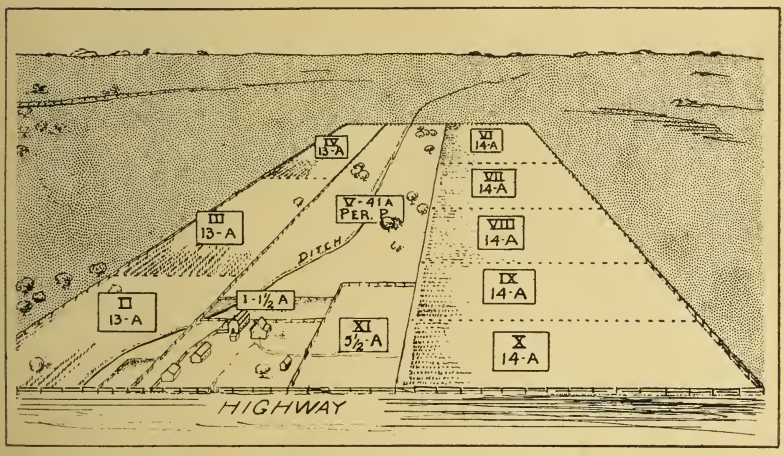
PLANS OF OTHER FARMS

Farm No. 1 has been considered in detail in order to show the method of laying out a farm plan. The original and revised plans of Farms Nos. 2 to 10 are presented to show a variety of conditions under which farm plans can be laid out.

The replanned farms and cropping systems which follow represent actual farms and have been carefully planned in consultation with the owners and approved by them. In most instances the plans are in actual operation, some of them running for several years.



FARM NO. 2.—ORIGINAL PLAN

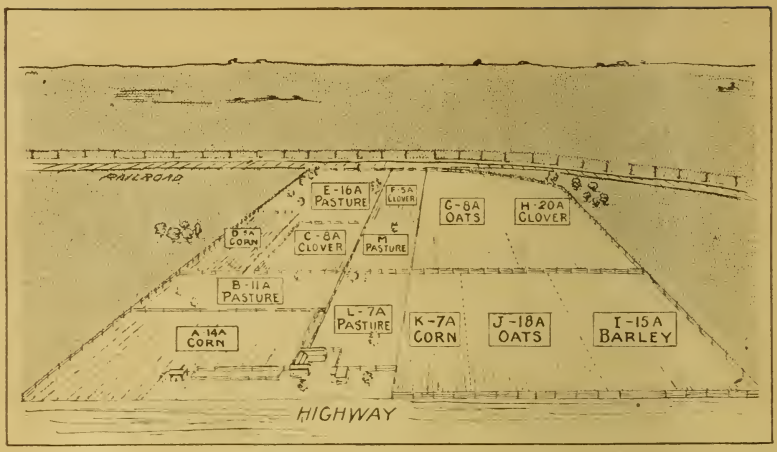


FARM NO. 2.—REVISED PLAN

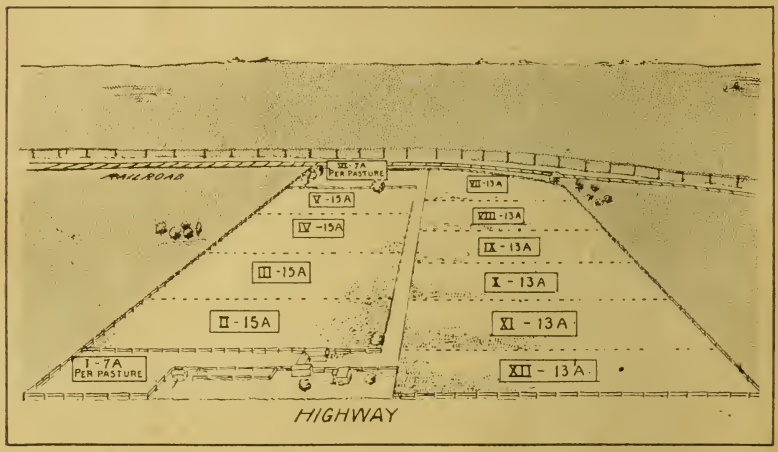
Major rotation: (1) Alfalfa* (2) Clover (3) Corn (4) Corn (5) Grain seeded to clover—Fields VI–X inclusive.

Minor rotation: (1) Clover (2) Corn (3) Grain seeded to clover—Fields II, III and IV.

* One field is set aside for alfalfa and remains in this crop as long as there is a good stand. When necessary to reseed, the alfalfa is shifted to another field. The remaining four fields adjust themselves to a regular four year rotation.



FARM NO. 3.—ORIGINAL PLAN



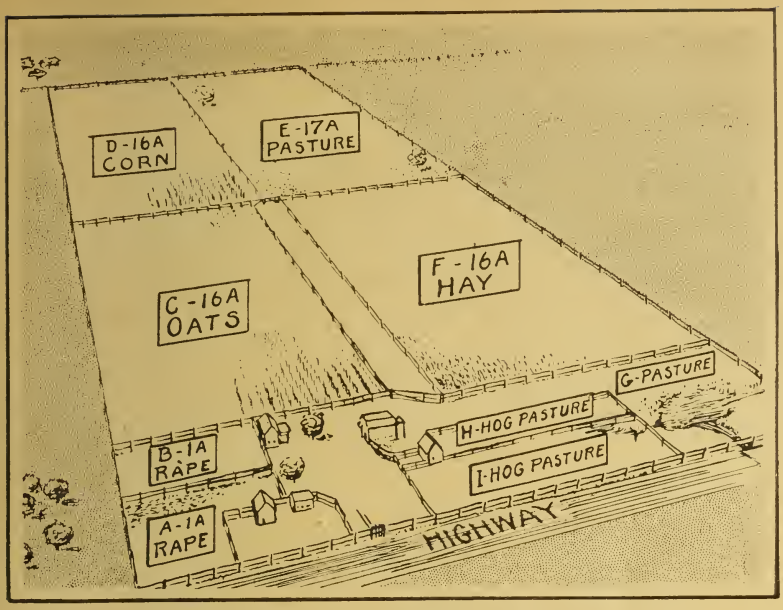
FARM NO. 3.—REVISED PLAN

Major rotation: (1) Alfalfa (2) Alfalfa (3) Alfalfa (4) Corn (5) Corn (6) Grain seeded to alfalfa.

Fields VII to XII inclusive

Minor rotation: (1) Clover and Timothy (2) Pasture (3) Corn (4) Grain seeded to clover and timothy.

Fields II to V inclusive



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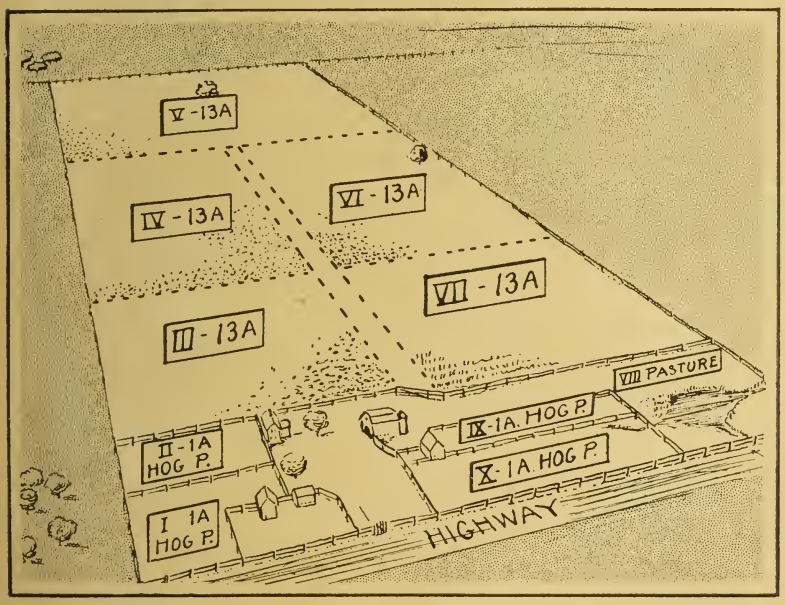


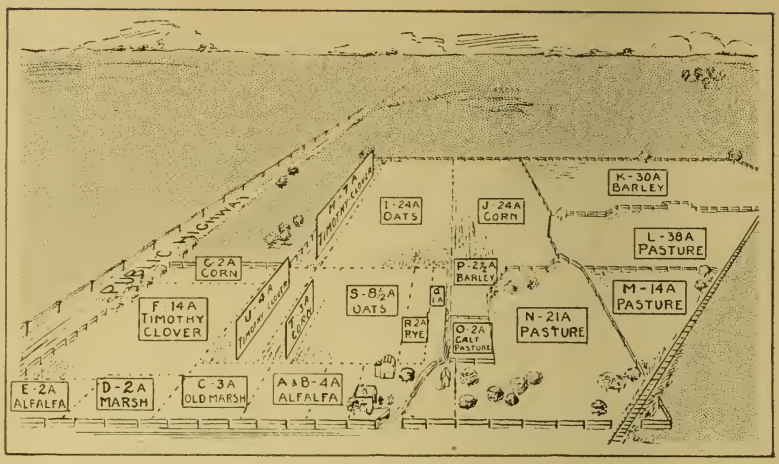
FARM NO. 4.—REVISED PLAN

Major rotation: (1) Clover (2) Pasture (3) Corn (4) Corn (5) Grain seeded to clover and timothy.

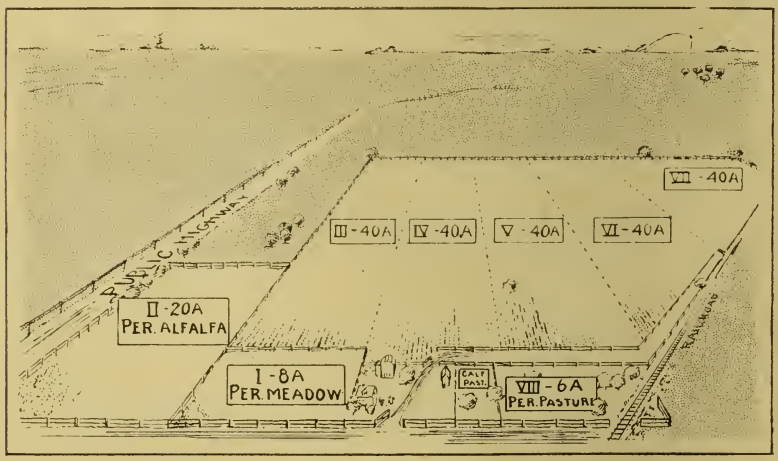
Fields III to VII inclusive

Minor rotation: (Hog Rotation) (1) Clover (2) Corn (3) Rape or succotash (4) Grain seeded to clover.

Fields I, II, IX and X inclusive



FARM NO. 5.—ORIGINAL PLAN



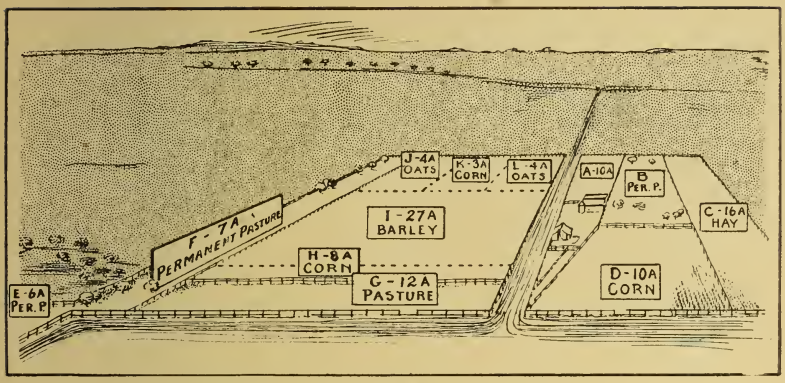
FARM NO. 5.—REVISED PLAN

Major rotation: (1) Alfalfa (2) Alfalfa (3) Alfalfa (4) Corn (5) Grain seeded to alfalfa.

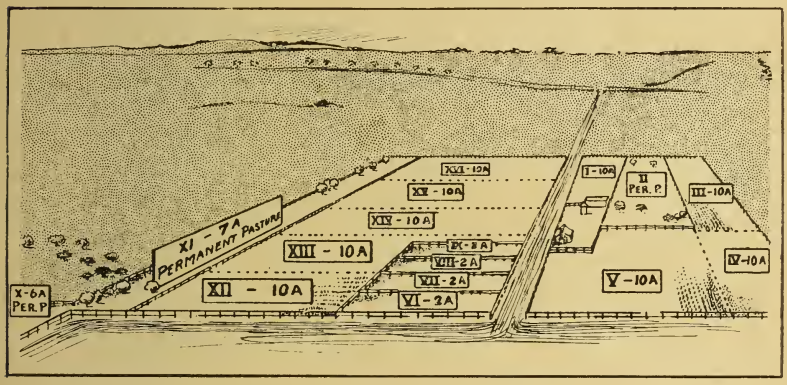
Fields III to VII inclusive

Fields I and II permanently in hay. Field VIII in permanent pasture.

Illustrates the plan of leaving part of the land out of the rotation.



FARM NO. 6.—ORIGINAL PLAN



FARM NO. 6.—REVISED PLAN

Major rotation: (1) Alfalfa (2) Alfalfa (3) Alfalfa (4) Corn (5) Grain seeded to Alfalfa.

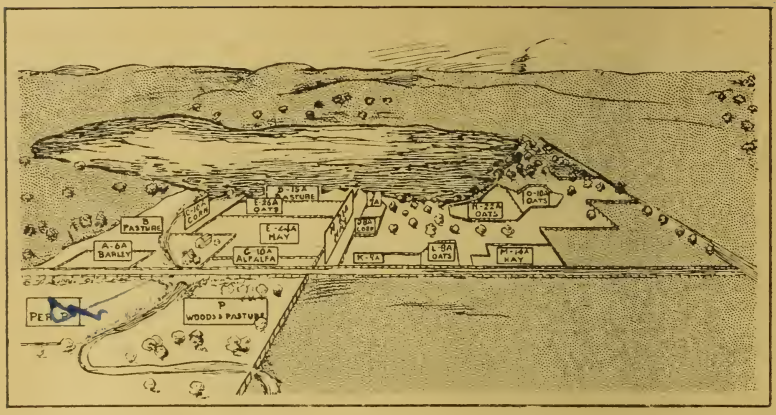
Fields XII to XVI inclusive

Minor rotation: (1) Clover and Timothy (2) Pasture (3) Corn (4) Grain seeded to clover and timothy.

Fields I, III, IV and V

Minor rotation: (Hog Pasture) (1) Clover (2) Corn (3) Rape or succotash (4) Grain seeded to clover.

Fields VI to IX inclusive



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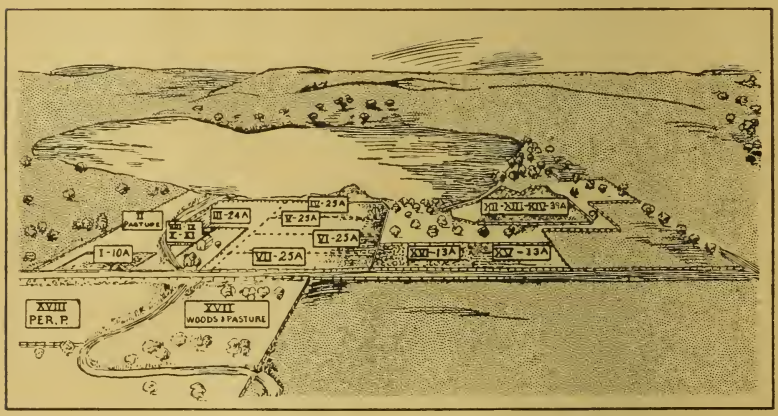


FARM NO. 7.—REVISED PLAN

Major rotation: (1) Clover and timothy (2) Pasture (3) Corn (4) Corn (5) Grain seeded to clover and timothy.

Fields III to VII inclusive

Minor rotation: (1) Clover (2) Corn (3) Corn (4) Grain seeded to clover.

Fields XII to XV inclusive

Minor rotation: (Hog Pasture) (1) Clover (2) Corn (3) Rape or succotash (4) Grain seeded to clover.

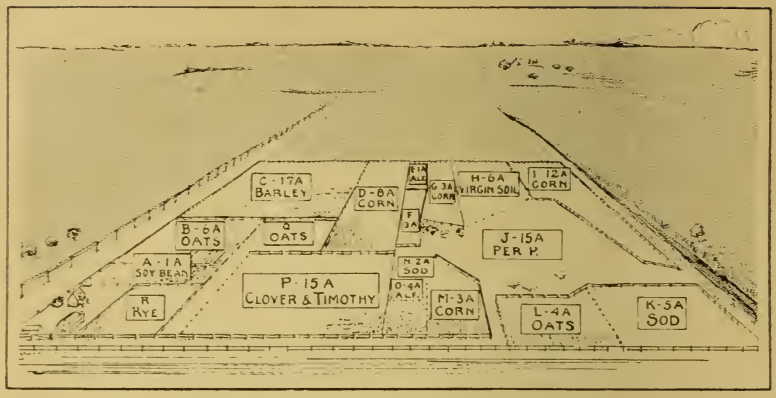
Fields VIII to XI inclusive

Special crops: Field I, permanent alfalfa; to be plowed and reseeded to alfalfa whenever necessary.

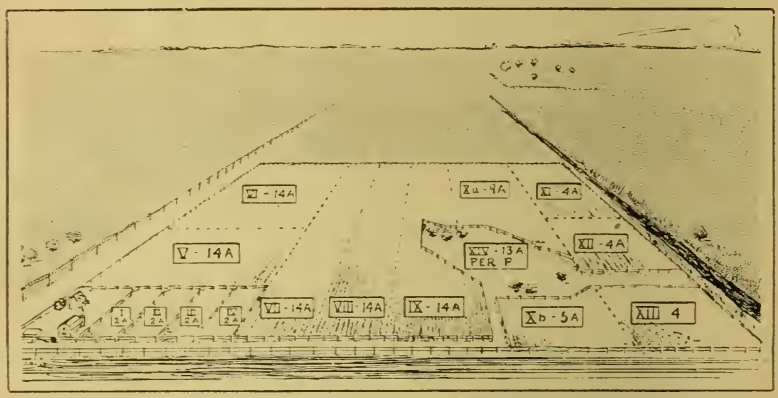
Field XVI, permanent alfalfa; or if desired this field can be substituted for one in the minor rotation (XII to XV) whenever the alfalfa runs out, and one of the latter used for alfalfa.

Plan Your Farm

It is very important for a farmer to have a broad, comprehensive plan or ideal before him in developing his farm, even though it may take years to realize it. Every move in rearranging fields, building fences, constructing buildings, planting fruit trees or shrubbery, can be made to fit in and adjust itself to this plan.



FARM NO. 8.—ORIGINAL PLAN



FARM NO. 8.—REVISED PLAN

Major rotation: (1) Alfalfa (2) Alfalfa (3) Alfalfa (4) Corn (5) Corn (6) Grain seeded to alfalfa.

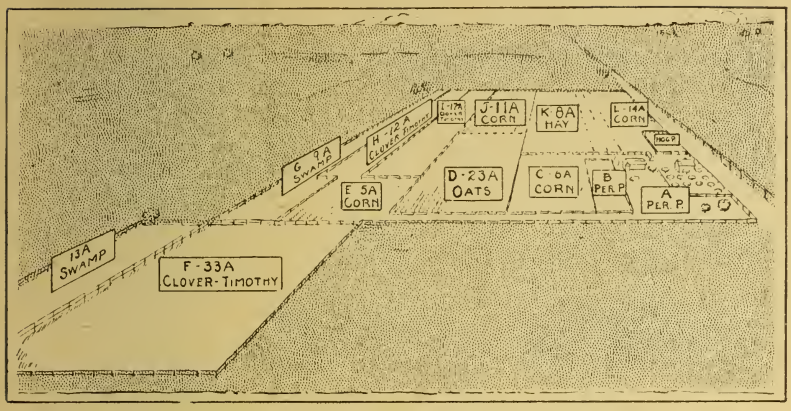
Fields V to X inclusive

Minor rotation: (Purebred seeds) (1) Clover (2) Corn (3) Grain seeded to clover.

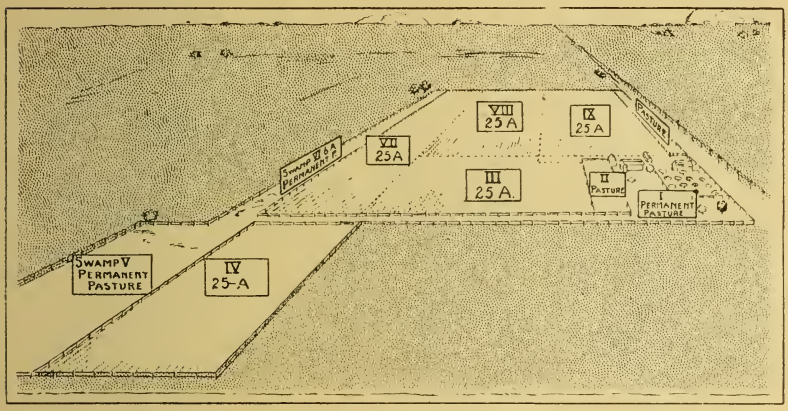
Fields XI to XIII inclusive

Minor rotation: (Hog pasture) (1) Clover (2) Corn (3) Rape or succotash (4) Grain seeded to clover.

Fields I to IV inclusive



FARM NO. 9.—ORIGINAL PLAN

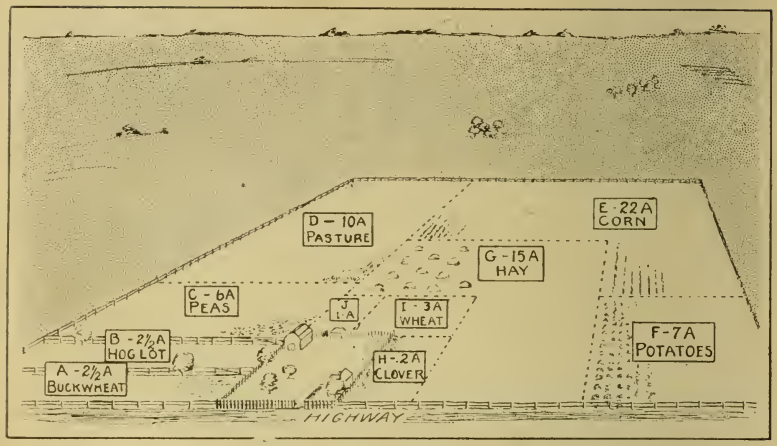


FARM NO. 9.—REVISED PLAN

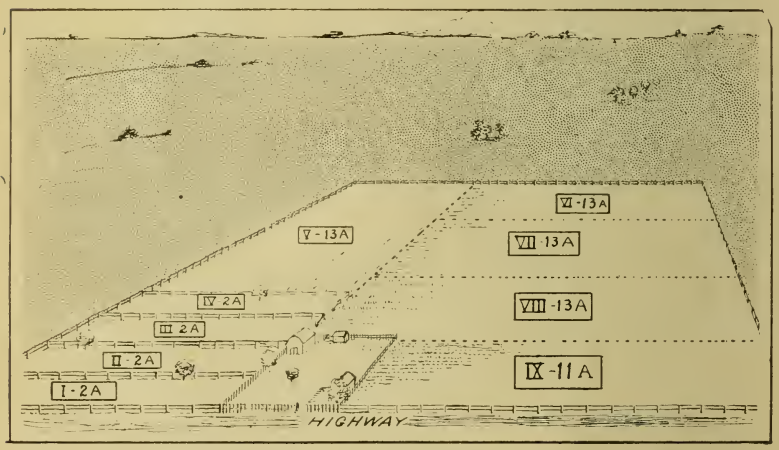
Major rotation: (1) Clover (2) Corn (3) Corn (4) Grain seeded to clover.

Fields III, IV, VII, VIII

Special crop: Field IX, permanent alfalfa; or if desired this field can be substituted for one in the major rotation whenever the alfalfa runs out and one of the latter used for alfalfa.



FARM NO. 10.—ORIGINAL PLAN



FARM NO. 10.—REVISED PLAN

Major rotation: (1) Clover (2) Corn (3) Corn (4) Grain seeded to clover.

Fields V to VIII inclusive

Minor rotation: (Hog pasture) (1) Clover (2) Corn (3) Rape or succotash (4) Grain seeded to clover.

Fields I to IV inclusive

Special Crop: Field IX, permanent alfalfa; or if desired this field can be substituted for one in the major rotation (V to VIII) whenever the alfalfa runs out and one of the latter used for alfalfa.

Ag. Sem.

Bulletin 329 March, 1921

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FIELD PEAS FOR WISCONSIN

SOME OF THE 250 FIELD PEA TEST PLOTS AT THE ASHLAND STATION.

AGRICULTURAL EXPERIMENT STATION
OF THE UNIVERSITY OF WISCONSIN

DIGEST

Field peas are one of Wisconsin's most profitable crops. They yield good returns as hay, pasture, silage or seed. Pages 3–8

The largest dry pea producing center lies in northeastern Wisconsin in the region adjoining Lake Michigan and Green Bay. A new pea belt is in process of development in the red clay region adjoining Lake Superior. Page 3

Dry peas are grown as cheaply as oats under modern conditions. On a ten-year average they pay better per acre than barley, oats, rye, wheat and hay. (1908–1917) Page 4

Peas as grain are higher in feeding value than corn, barley, and oats. As hay, they outrank all others even alfalfa. Mixed with oats for silage they are equal to corn in feed value and outrank corn in yield on heavy clay soils. Page 7

Peas are adapted to a variety of soils but grow especially well on loams and clays high in lime. Page 9

Well-drained land is necessary for peas. Proper plowing helps to provide this. Page 10

Peas should be sown early on a well-prepared seed bed at a uniform depth which ranges from 2 to 3 inches. Small sized peas require 6 to 8 pecks an acre for seed; medium sized peas require 8 to 10; and large sized peas require 12 to 14 pecks. Pages 11–12

Peas should be cut with the mower with attachment. They should then be stored under a good roof and threshed with a properly fitted grain thresher. Pages 13–15

Proper rotations and often inoculation are necessary for profitable returns. Pages 18–19

The best varieties to plant are pedigree strains of Green, Scotch, and Marrowfat. Only one variety should be grown in a locality to avoid mixing. Good seed may be secured through the Ashland Branch Experiment Station. Pages 23–24

Field Peas for Wisconsin

E. J. Delwiche

Suitable soil and climatic conditions help to make Wisconsin the leading state in the production of both field and canning peas.

Field peas are one of the most profitable crops, whether grown for the market or for livestock feed. As hay, pasture, silage or seed, field peas yield good returns. The varieties grown for human consumption pay better than any cereal grain crop grown.

Peas are neither a difficult nor an expensive crop to grow. The crop is machine-handled. Cost records show that on the acre basis peas cost less than oats to produce.

Where Peas Grow Best in Wisconsin

The leading dry peas section of Wisconsin is the eastern and northeastern part of the state. The greater part of the crop is produced north of the southern boundaries of Calumet and Manitowoc Counties, in the counties bordering on Lake Michigan, and in the basin of the Fox River and other streams emptying into Green Bay. The comparatively cool summer climate of this region and the prevailing clay soil well supplied with lime are the chief factors favoring production. Tests carried on for several years in cooperation with growers in the heart of this area show that when proper attention is paid to seed, soil, and rotation the pea crop is just as profitable as it ever was.

Table I.—Acreage and Production of Dry Peas in Wisconsin

Year	Acreage	Production (bushels)	Acre yield (bushels)
1899	68,819	1,098,819	15.8
1909	78,017	1,165,055	14.9
1919	66,169	882,252	13.3
1920	55,760	1,062,783	19.6

Experiments and demonstrations made by the Agronomy Department at the Ashland and Superior stations and in co-operation with farmers, show conclusively that another compact seed pea area can be developed in Wisconsin.

PEAS AMONG BEST PAYING CROPS

Peas are among the best paying cash crops for the red clay soil section of northern Wisconsin. Acre for acre, peas pay better than any cereal grains grown in the state. (See Table II.)

TABLE II.—A COMPARISON OF WISCONSIN CROPS (1908 TO 1917 INCLUSIVE)

Crop	Average acre yield in bushels	Average price per bushel Dec. 1	Average value per acre	Estimated value of straw	Total value
Scotch peas	16.0	$2.53	$40.48	$4.00	$44.48
Barley	28.9	.74	21.39	3.00	24.39
Oats	35.4	.43	14.22	4.00	18.22
Rye	17.4	.89	15.40	4.00	19.40
Wheat	19.3	1.09	2.24	4.00	25.25
Hay	1.56 to t	12.00	17.76		17.76

PEAS ARE GROWN AS CHEAPLY AS OATS

There is a general impression that growing peas requires much hard labor. Under modern methods, as a matter of fact, the crop is planted, harvested, unloaded from the wagon, and threshed by machinery. Cost accounting for the different crops

TABLE III.—COSTS AND RETURNS FROM GREEN FIELD PEAS AND OATS

Year	Value of crop		Cost to produce		Net returns per acre	
	Oats	Peas	Oats	Peas	Oats	Peas
1914	$18.33	$42.66	$10.53	$12 23	$7.80	$30.43
1915	54.04	53.36	11.14	11.70	42.90	41.66
1916	38.80	99.84	11.75	10.90	27.05	88.94
1917	68.00	108.85	17.50	10.27	50.50	98.58
1918	37.13	52.40	15.04	12.17	22.09	40.23
1919	41.25	38.25	18.02	11.55	28.23	26.70
Average for six years	$42.93	$65.89	$14.00	$11.47	$28.93	$54.42

at branch and demonstration stations reveals the fact that peas cost no more to grow than oats on the acre basis. The results in Table III were obtained at the Superior station in 1914–1919, by men who had had little, if any, previous experience in growing the crop. As the grower becomes more proficient in growing peas the cost of production is greatly lowered. The most expensive item for this locality is plowing, which is done in the fall.

FIG. 1.—A HEAVY PEA CROP AT SUPERIOR STATION
Luxuriant growth of one of the best pedigree strains.

SOUP TYPES OF PEAS PROMISING

In 1908 preliminary tests were made on the station farm near Ashland. The soil there is of the red clay type. The results were so satisfactory that work with peas was strongly emphasized at this station and at the Superior demonstration station. The acre yields at Ashland have averaged 22.6 bushels for the Green and 22.9 bushels for Scotch for 10 years (1908–1919). At Superior the average acre yield for eight years was 21 bushels for soup pea varieties and 19 bushels for sweet wrinkled canners. On Kennan loam soil at the Rusk County demonstration station at Conrath the Green variety has aver-

aged 20½ bushels an acre for the last six years. In a few seasons, as in the case of all crops, yields have been low, but the average acre yield has been approximately 5 bushels higher than the average for the state for the same period. These results clearly indicate the possibilities for growing peas of the soup types.

PRODUCTION OF SEED PEAS

Still another great possibility is the production of seed peas of canning varieties to supply the needs of our canning factories. At the present time by far the greater part of the seed used is shipped in. The results of tests made with the Horsford variety, a sweet wrinkled type, and Alaska, a well known round variety, show good seed producing possibilities. At Ashland the average yield for 4 years was 15.6 bushels for Horsfords and 18.3 bushels for Alaskas.

SOILS ADAPTED TO PEAS

The growing of peas under irrigation entails greater expense than under humid conditions. On the other hand, on our clay soils considerable attention to drainage should be given, for peas are easily damaged by extreme wetness. Without question, however, if the grower in northern Wisconsin will give the time and care to growing peas that is required under irrigation, he can produce fully as good crops on land which, at the present time, costs much less. Already several seed companies have begun to grow peas under contract with very satisfactory results. In one instance, a grower of sweet wrinkled peas grew 100 bushels on 3½ acres for which he received $6 a hundred pounds.

This northern region, adapted to growing seed peas, coincides with the belt of clay and loam soils of the Superior type in Douglas, Bayfield, Ashland and Iron Counties. The loam soils of north central Wisconsin are also well adapted to peas. The results at the Conrath station, and cooperative tests in Price, Lincoln, and Langlade Counties, all point to the possibilities in this particular region.

The amount of cleared land in Upper Wisconsin is comparatively small as yet, but it is steadily increasing. Since no insect pests nor destructive fungus diseases have thus far in-

fected this region, it is especially well adapted to the production of seed peas or dry peas of the field or canning types.

PEAS ARE EXCELLENT FEED FOR LIVESTOCK

The comparative feeding value of peas in relation to other Wisconsin grown grains is shown in Table IV. Peas outrank barley, corn and oats in protein nutrients and are second only to corn and barley in total nutrient content. Fed with a low protein feed such as barley, oats or corn, peas are very valuable. Cured for hay, peas are higher in feeding value than any other hay grown, including alfalfa.

TABLE IV.—POUNDS OF DIGESTIBLE NUTRIENT IN 100 POUNDS OF FEED*

Crop	Protein	Carbohydrates	Fat	Total	Nutritive ratio
Grain					
Peas	19.8	55.8	0.6	76.2	1:3
Corn	7.5	67.8	4.6	87.7	1:10.4
Barley	9.0	66.8	1.6	79.4	1:7.8
Oats	9.7	52.1	3.8	70.4	1:6.3
Hay					
Pea	12.2	40.1	1.9	56.6	1:3.6
Oat-pea	8.3	37.1	1.5	48.8	1:4.9
Alfalfa	10.6	39.0	0.9	51.6	1:3.9
Clover	7.6	39.3	1.8	50.9	1:5.7
Timothy	3 0	42.8	1.2	48.5	1:15.2
Silage					
Corn	1.1	15.0	0.7	17.7	1:15.1
Oat-pea	2.8	12.6	1.0	17.6	1:5.3
Pea cannery refuse	1.6	11.6	0.8	15.0	1:8.4

*Adapted from Henry and Morrison's "Feeds and Feeding."

PEAS OR OATS MAKE GOOD SILAGE OR HAY

Peas and oats mixed in about equal volume and sown either broadcast or in drills so they can be cultivated, yield excellent returns as hay or silage. At the Superior station, peas and oats planted in double drills 30 inches apart and cultivated twice yielded more than 9 tons of forage to the acre. In 1918, at Con-

rath, Rusk County, on loam soil, peas and oats yielded 4½ tons of thoroughly cured hay to the acre, or an equivalent to 17 tons of silage.

Oat-pea silage contains approximately the same amount of total digestible nutrients to the acre as corn silage. Where corn is not a sure producer, peas and oats for silage are valuable to replace or supplement corn as a silage crop. The same combi-

FIG. 2.—PEAS AND OATS ARE AN EXCELLENT SUBSTITUTE FOR CLOVER

This combination may also be used successfully for ensilage, particularly in sections where corn is not successful.

nation is an excellent substitute for clover when it has not been provided for in the rotation or when it kills out.

Whether the crop is used for feed or is sold as a cash crop, depends on the market price for peas and other grains.

At the present time, December 1920, peas are worth $.0225 a pound as compared to $.017 for barley and $.0125 for oats. Under such conditions peas should be sold and barley bought for feed. In some localities the crop can more profitably be grown for hay than for seed.

HOW TO GROW PEAS

LOAM OR CLAY SOIL BEST

Peas generally grow best on loams and clays but they may be grown on most Wisconsin soils. On warm sandy soil the crop suffers in dry hot weather because rapid evaporation causes the plants to wilt and finally dry up. On soil of low moisture-holding capacity the pea crop should be cultivated as corn and potatoes are. Some of the finest seed peas are grown in this way.

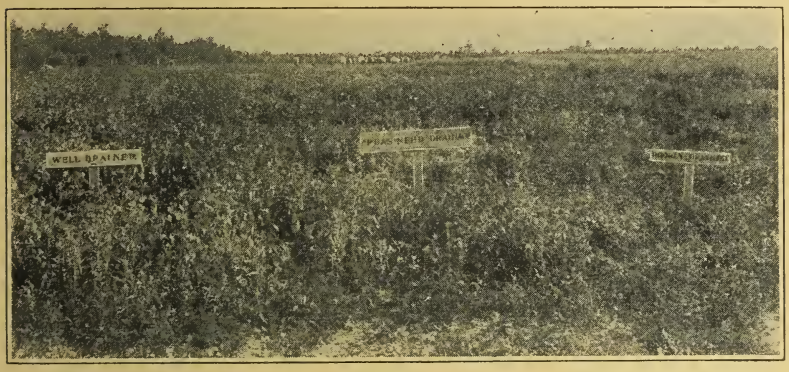

FIG. 4.—PEAS NEED DRAINAGE

Land subject to overflow or deficient in surface drainage should be avoided but clay soils after they are drained are very satisfactory.

At the Spooner station on sandy loam soil peas were grown and cultivated a few times in June. The yields were very satisfactory, and the quality of the seed excellent. (Table V). The season was not especially favorable, for the month of June was hot and dry in 1919, while July 1920 was exceptionally so. In comparison with soybeans, peas yielded much better in 1920 while in 1919 soybeans gave twice the return per acre.

TABLE V.—VARIETY TEST WITH FIELD AND CANNING PEAS AT SPOONER STATION—1919–1920—(PRODUCTION IN BUSHELS 60 POUNDS WEIGHT)

	Ped. 108 Green	Ped. 9152 Scotch	Ped. 108 Golden Vine	Ped. 10783 Multiplier	Common Alaska	Ped. 13.95 Alaska	Ped. 10452 Horsford	Ped. 108 Canadian Beauty Marrowfat	Admiral	Arthur
1919...	20.6	21.0	21.5	13.8	13.9	15.7	16.0	16.7	13.6	20.5
1920...	11.5	15.8	16.5	14.2	7.2	6.0	8.1	12.7	.....	12.5

PEAS NEED WELL-DRAINED LAND

Peas are easily damaged by standing water. Land subject to overflow or deficient in surface drainage should be avoided, but wet clay soils after they are well drained are very satisfactory for peas. On the heavy red clay soils of northern and eastern Wisconsin excellent results are obtained by plowing in lands from 25 to 35 feet wide, leaving open dead furrows to carry away the surface water. Experiments at the branch stations have clearly shown such a practice is very practical and pays well.

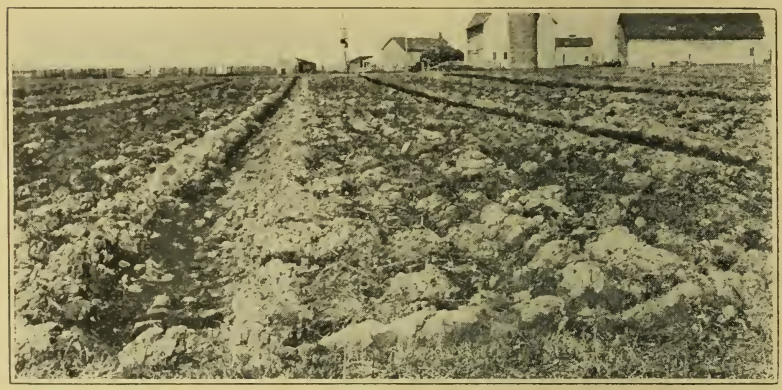

FIG. 4.—OPEN DEAD FURROWS FOR DRAINAGE

Method of plowing in narrow lands. Colby loam soil at Marshfield.

PLOW FIELD FOR PEAS IN FALL

Land for peas should be plowed in the fall if possible. This is particularly necessary on heavy clays low in organic matter. Fair results are also obtained with very early spring plowing of good sod land. When plowing is done in the spring, care should be used to get the soil well-firmed with some such implement as a roller or planker. One of the chief objections to spring plowing is that seeding has to be delayed a week or more to permit the freshly plowed land to properly warm up and weather.

PEAS NEED A GOOD SEED BED

Peas require a deep, well-prepared seed bed. The ground should be worked to a depth of at least 5 inches. Experiments

with peas at the Ashland branch station prove that it is not desirable to pulverize heavy clays until very fine for there is danger of the land baking into a hard crust when heavy rains follow soon after seeding. The soil should be of a crumby, not powdery, texture. On the other hand clods and large lumps are undesirable because they interfere with the mower at harvest time.

The ground should be well leveled so as to do away with hollows and prominent ridges. Stones, roots, and trash should be hauled off the field immediately after seeding, for they interfere with the use of machinery at harvest time. If the ground is rather lumpy it is a good plan to roll it after the peas are well up. Rolling should not be done when the ground is at all wet.

SOW SEED PEAS EARLY

Peas, with the exception of the wrinkled kinds, should generally be sown as soon as the ground is dry enough to work well. Clay soils work best in the early spring before the mellowing effect of freezing and thawing has been neutralized by heavy rains. If seeding is not done early there is danger of rains delaying seeding operations. At the Ashland and Superior stations peas were successfully sown from March 31 to May 21. The season and not the calendar should be the guide. Wrinkled peas should not be sown before May 1 unless the season is warm, for if cold, wet weather should follow seeding there is danger of the seed rotting in the ground.

SOW AT UNIFORM DEPTH

Peas should be sown at a uniform depth if they are to ripen evenly. Uniform seeding requires that the ground be level and well-fitted to a uniform depth. The grain disk drill is best for seeding since it covers all seed to about the same depth. If neither drill nor seeder is available the peas may be sown by hand and covered by going over once only with disk, spring tooth harrow or cultivator. A second harrowing will uncover much of the seed.

SOW ENOUGH SEED

Size of seed, time of planting, soil condition, also use of crop and the viability of the seed decide the rate of seeding. The rates for grain production for the different varieties are:

1. Small peas, such as Golden Vine, Multiplier, and French June, 6 to 8 pecks per acre.

2. Medium-sized peas, including Green and Scotch, 8 to 10 pecks per acre.

FIG. 5.—THE GRAIN DRILL IS BEST FOR SOWING PEAS

This implement covers all peas to a uniform depth.

3. Marrowfats, 12 to 14 pecks per acre.

When the peas are sown alone for hay the amount of seed used should be increased about 25 per cent. When peas are sown with oats for hay, from 1½ to 2 bushels of peas and from 1 to 1½ bushels of oats should be used to the acre. These directions have been worked out from the results obtained at the branch experiment stations.

The rates given are for high-germinating seed sown with the grain drill. If broad-casted, the amount of seed should be increased about one peck for each acre. When peas are sown

on poorly fitted, cloddy land more seed per acre is required. Late seeding also requires more seed, because the peas seldom stool much if sown late in the season.

The high prices of seed peas have kept many growers from sowing enough seed. This is poor economy, for if a pea stand is thin, weeds develop rapidly and prevent a normal growth of the pea vines. A good pea crop must occupy all the ground.

Depth to Sow Peas

On loam soils peas should be sown to a depth of 3 inches. On heavy clay soils 2 inches is deep enough unless the ground is very dry, in which case planting should be deeper. The seed should be placed well down in moist soil.

On the rolling type of red clay land, unless special attention is given to the hard knolls, the ground may be fitted too shallow to permit a sufficiently deep planting.

Harvest Seed Peas With Machinery

Peas are easily and economically harvested with machinery. The ordinary mower equipped with lifting guards and windrowing rods is used for harvesting in the chief pea-growing sections. The lifting guards raise the vines so that they can be cut without cutting the pods. The windrowing rods serve to roll the pea vines in a windrow well out of the way of the team when it comes back on the next round. Such an attachment costs about $20.

In order to harvest with the mower the crop should be allowed to mature well before cutting, as the vines windrow best when dry. Work should begin after the dew has dried from the vines.

Where the seed bed was properly prepared the cost of harvesting peas is not greater than for any other grain crop. One man and a team can do all the work since there is no shocking to do.

Moisture Damages Seed Peas

Care should be taken, especially with the Scotch and Green varieties, not to let the pods remain for any length of time in contact with the wet ground. The damp soil dissolves the coloring matter in the peas, thus bleaching them. This lowers the market value.

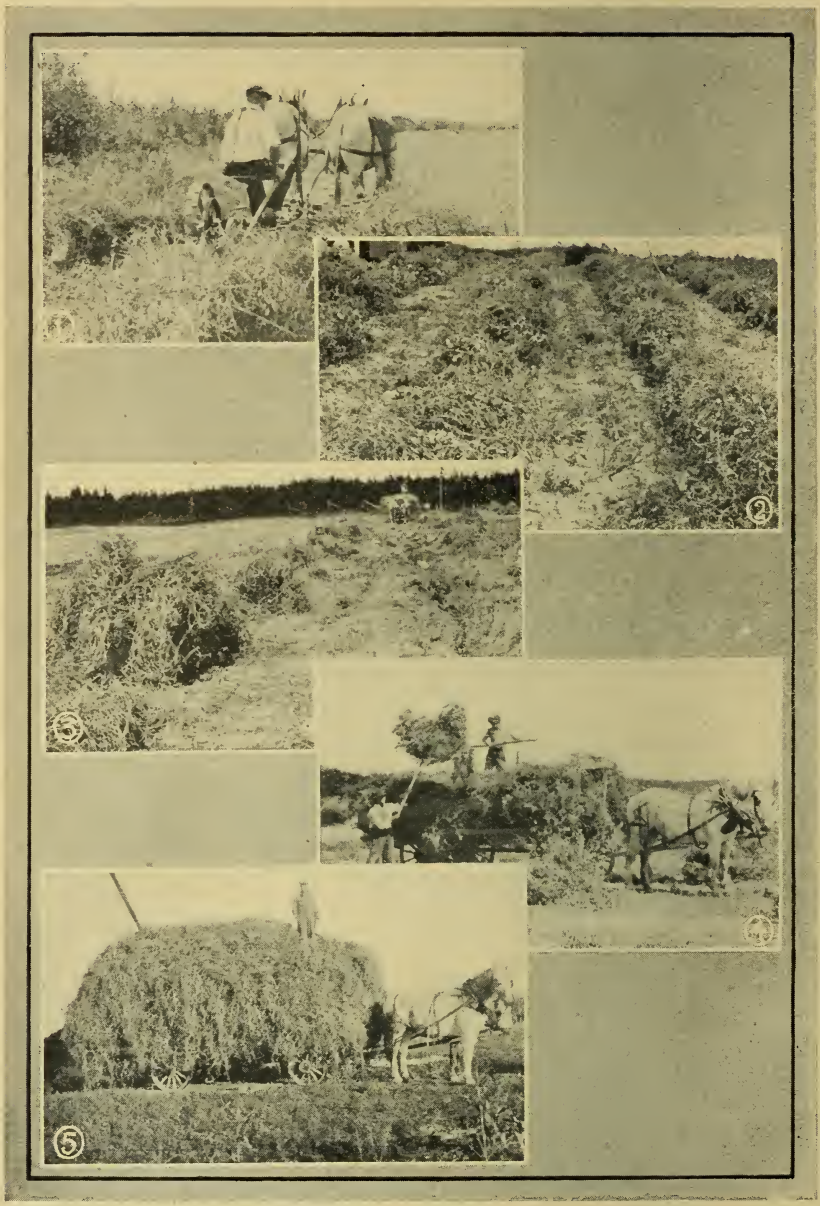

FIG. 6.—HARVESTING PEAS

(1) The mower with windrowing and pea lifting attachments saves hand labor and harvests peas quickly. It is essential where fields exceed 4 acres.
(2) Windrows of peas left after using method shown in Fig. 1. Peas were left until dry enough to haul.
(3) Peas in bunches ready to load.
(4) Loading peas.
(5) A well-made load.

In sunny weather well-ripened peas may be hauled to the barn a day or two after cutting. In case of rain the vines should be turned as soon as the tops of the windrows are dry. When the sun shines and the wind blows after a rain the vines dry rapidly and often are ready to haul in the following day.

Just before hauling, two or three windrows are put together without cocking. Loading is done from both sides if the wind permits. The dry vines should be stored under cover, in barn or shed, and not in the stack. A board roof built on top of a

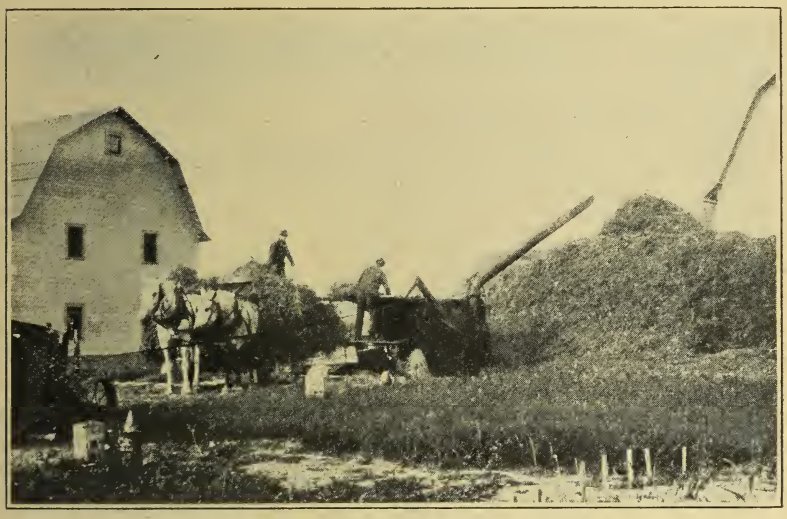

FIG. 7.—GRAIN THRESHER USED FOR PEAS

The cylinder must be run at a much lower rate of speed than for oats and barley.

rectangular stack finished so as to give the roof the proper slope is fairly satisfactory. The practice of threshing from the field is not recommended in Wisconsin for it almost invariably results in loss in both quantity and quality of seed on account of rainy weather which necessitates repeated turning.

THRESH PEAS WITH GRAIN SEPARATOR

Peas are successfully threshed with the grain thresher when it is properly adjusted. To prevent cracking the peas the cylinder must be run at a much lower rate of speed than for oats and barley. This is done by using a larger pulley to drive the separator cylinder. A split wood or steel pulley of sufficiently large bore to fit on the regular pulley may be used for the purpose.

Peas thresh best at a speed about 40 per cent lower than for small grains.

To clean the peas properly it is also necessary to use a large pulley for driving the separating mechanism in order to compensate for the reduced speed of the cylinder shaft. One or two rows of concave teeth and steel or wood blanks are used. Adjustments should be made according to the peas. A properly adjusted separator threshes peas clean practically without cracking.

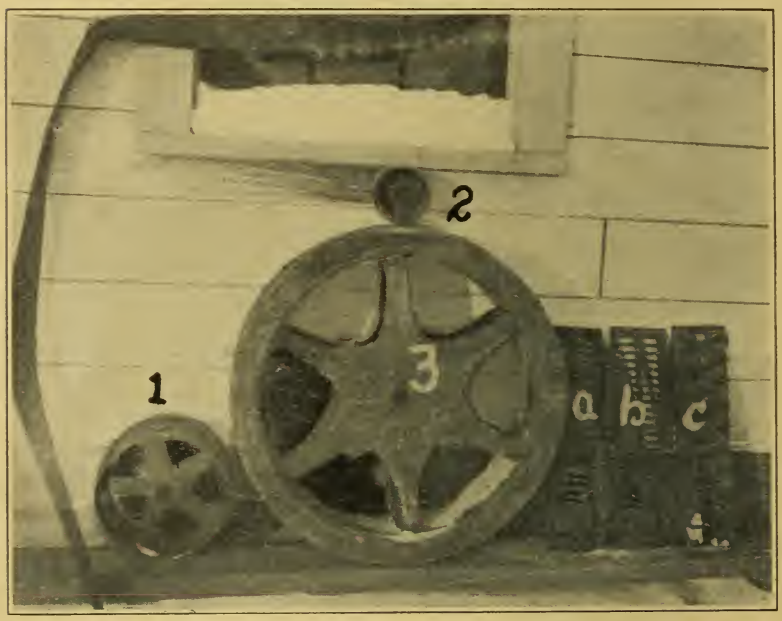

FIG. 8.—LARGE PULLEYS USED IN PEA THRESHING

These are substituted for the regular pulleys used in grain threshing. The blank concaves a and c may be used in place of the regular concaves, such as b, when necessary.

INOCULATION OF PEAS

Peas being a legume crop cannot attain full development unless there is a supply of the specific nitrogen fixing bacteria in the soil. This may be lacking entirely, or it may be there because closely related plants such as wild or tame vetches, or so-called wild peas grew on the land before it was broken. This condition frequently obtains in Upper Wisconsin. The proper bacteria may have also been introduced by a previously grown

pea crop. If, however, the nodule forming or nitrogen fixing bacteria are not known to be there they should be supplied. In order to test out the need of inoculation, tests were made in 1920, on virgin soil, (for peas) at Ashland and Spooner; on land where peas grew three years previously at Marshfield; and on virgin land, in cooperation with a canning company near Sanborn, Wisconsin.

The land on which the tests were made were, in each case, uniform in character. In each instance the uninoculated plots were put in first. The cultures for inoculating were obtained from the Department of Agricultural Bacteriology, (for cultures, address Experiment Station, Madison) and were applied strictly according to directions. Soil used for inoculation was taken from a well inoculated pea field on which peas grew in 1919. The soil was thoroughly mixed with the seed.

TABLE VI.—PEA INOCULATION TESTS

ASHLAND BRANCH STATION

Plot Number	Yield per plot pounds	Yield per acre pounds
1 and 4—Culture inoculation	160	1,333
2 and 5—Soil inoculation	135	1,125
3 and 6—No inoculation	122	1,016

SPOONER BRANCH STATION

Plot Number	Yield per plot pounds	Yield per acre bushels
1—Culture inoculation	10.5	7.6
4—Culture inoculation	12.5	8.9
2—Soil inoculation	14.0	10.0
5—Soil inoculation	11.5	8.2
3—No inoculation	12.5	8.9
6—No inoculation	11.0	7.9

MARSHFIELD BRANCH STATION

Plot Number	Yield per plot pounds	Yield per acre bushels
1 and 4—No inoculation	26	10.4
2 and 5—Culture inoculation	26	10.4
3 and 6—Soil inoculation	24.5	10.0

In the test with the canning company one acre was first planted without inoculation, and the balance of the field, about 10 acres, culture inoculated. Proper inoculation was insured. No yields were taken, but a thorough examination of the crop failed to show any benefit due to inoculation. There was a thrifty growth in each case, and plenty of nodules present in the pea roots.

In the test at the Ashland station culture inoculation gave the best results; at Spooner, soil inoculation gave the best average, and at Marshfield, the same was true.

While these results are not sensational they show the benefit of inoculation. It is largely a matter of insurance. On new land especially, inoculation seems important.

PRACTICAL METHODS FOR INOCULATING PEAS

Two methods of inoculation are followed. One is by the use of soil from a field where bacteria were produced in abundance. A little of the soil is mixed with the peas just before planting. Enough dirt should be used to coat all seeds with it.

The other method is by treating the seed with a pure culture. The Department of Bacteriology at the Experiment Station, Madison, supplies enough culture to inoculate one bushel of seed for 25 cents. Directions are given with the culture.

Proper inoculation is important for it may mean the difference between success and failure. New land often lacks the proper bacteria.

USE MANURE OR FERTILIZER IF NECESSARY

On heavy clay soils low in humus a light top dressing of manure is often beneficial. If much mineral matter has been removed through several years of cropping, this deficiency should also be supplied by a proper fertilizer since peas are high in mineral matter.

PEAS FIT WISCONSIN ROTATIONS

Peas are admirably adapted for growing in rotation with small grains, cultivated crops, and hay or pasture crops. An excellent four-year rotation which is proving particularly well adapted to the red clays of northern Wisconsin is: small grain,

clover for hay and pasture, cultivated crops, and peas. The pea stubble is disked and fitted for grain without plowing. Winter wheat or winter rye is sown immediately after the peas are removed. The growing of peas after a cultivated crop largely avoids trouble with grass and weeds in the pea crop and in the succeeding grain crop. If desired, the hay crop may be left for two years instead of one, making a five-year instead of a four-year rotation.

A second rotation, which is commonly followed in eastern Wisconsin, is; clover; mixed hay; peas; cultivated crops; small grains seeded to clover.

The first rotation has the advantage of saving plowing for winter grain, a very desirable feature on heavy soils which are hard to plow in summer.

At the Marshfield station rotation studies begun in 1917 show clearly the need of proper rotation for peas. In 1920 peas after peas yielded only 9 bushels per acre, peas after corn, 12 bushels, and peas on sod, 13.1 bushels. At the Ashland Station root rot severely affected the pea crop where only a short period intervened between successive pea crops. Peas after peas, and peas following peas inside of three years, were badly affected; where four years had elapsed between succèssivè pea crops the amount of root rot was very small; and where peas had not been grown previously no root rot developed.

Peas leave the soil in excellent condition for a small grain crop. Reports show that oats grown after peas gave better returns than after any other crop tried. If properly inoculated they will add to the soil in one season a large amount of both nitrogen and humus.

Station Tests and Improved Varieties of Peas

Since 1908 when variety tests and breeding work were begun at the Ashland branch station, several hundred strains and varieties from various sources have been tested. A few of the best have been kept. Table VI shows yields for varieties and strains which have been grown since 1914 and were still under test in 1920, and for two varieties which have been grown since 1917 only.

Most of the varieties retained are pure line strains. They are the best for the variety they represent. New varieties have been

FIG. 9.—ROTATIONS WITH PEAS

(1) Peas after peas; (2) Peas after corn; (3) Peas after clover; (4) Wheat after wheat; (5) Wheat after peas

produced by crossing, several of which are superior to the parent plants, but since these have not been grown in sufficient quantity to distribute they are not included in the table. In a very few years the Experiment Station expects to have enough seed to distribute to growers:

The yields for 1916 and 1919 (Table VI) were abnormally

TABLE VII.—VALUE OF PEDIGREE STRAINS

Variety	Green	White Marrowfat	Small Yellow	Scotch
	Bu. per acre	Bu. per acre	Bu. per acre	Bu. per acre
Common stock	37.3	32.9	33.6	31.4
Pure line stock over pedigree stock	50.0	36.5	38.0	50.0
Increase per acre, pedigree over common	12.7	3.6	4.4	18.6
Per cent of increase	34.0	11.0	14.0	59.0

Note: Average increase for different varieties is 30 per cent.

low, due to excessive rainfall during June and July. In 1916 a drainage ditch above the plots overflowed, letting a flood of water sweep over the field. For this reason the results in 1916, while comparable to some extent for the different varieties, do not show the possible yields. Excluding 1916 and including six years only gives a more accurate idea of the possibilities of pea culture.

A study of the tests shows that the Golden Vine, which belongs to the common yellow group, makes the best yield. The Multiplier is another good yielder. These varieties are good stock peas to grow for hay, silage or grain. The Pedigree 108 Green is just as well adapted for stock feed and is, besides, one of the best sellers for soup peas. For these reasons the Pedigree Green is preferable. Plenty of good seed is available.

Pedigree Scotch No. 9175 and the Pedigree Green strains, the standard green peas of eastern Wisconsin, are the next highest yielders. They are high-class varieties suitable for human consumption besides being useful for stock feed, as hay, ensilage, or grain. The Green variety is three or four days earlier in maturing than the Scotch. Tests made at the Hancock and Spooner stations indicate that the Green variety is well adapted to light soils. The Scotch is an excellent variety for the most

favorable pea-growing sections, and is especially well adapted to clay soils. Ordinarily, it sells for a somewhat higher price than the Green.

The Marrowfat is another group of high-priced soup peas. These are represented by Pedigree strains of the Potter, Canadian Beauty, and Arthur varieties. The Potter averages somewhat higher in yield than the Canadian Beauty. As the Arthur has been tested for only three seasons, no conclusions as to yield are justified. The Marrowfats are usually quoted somewhat higher than the Green and Scotch varieties. Their larger size—which makes them more liable to cracking in threshing—coupled with lower average yields makes them less desirable for the average grower.

Varieties Recommended

The **Scotch** strains are recommended for heavy soils for a market pea. For lighter soil types the **Green** is best. It may be grown for feed or for the market. The **Marrowfats** are suited where the best care can be given. The **common yellow** kinds are suited for stock feed. The **Green and Golden Vine** do well to grow with oats for hay or silage.

DON'T MIX VARIETIES

It is of the utmost importance to keep varieties of peas free from mixtures. For this reason growers are most strongly urged to specialize in one variety. Communities ought to make a selection and then stick to it. This is necessary to keep from mixing varieties at threshing time and to enable growers to ship in carloads. Unless one farmer alone can grow 600 to 700 bushels, or is located near a main market, he cannot afford to grow a variety different from his neighbors. In new sections especially it is absolutely necessary to club together and grow one kind, and thus be enabled to ship full cars.

The Ashland branch station has started several farmers in the different pea sections of Wisconsin to growing the pedigree strains. Farmers desiring such seed can get it by writing to

the Experiment Station there. In some cases this stock can be purchased from seedsmen. There is an excellent opportunity for Upper Wisconsin farmers in those regions where peas do well, and so far are free from disease and insects, to engage in seed pea production. Growing for the seed market, however, makes it still more necessary if the community is to specialize on one variety.

TABLE VI.—VARIETY TEST WITH FIELD AND SOUP PEAS AT THE ASHLAND BRANCH STATION (1914–1920)

Year	Ped. 9.152 Scotch	Ped. 10775 Multiplier	Ped. 108 Canadian Beauty	Ped. 9175 Scotch	Ped. 108 Potter	Ped. 108 Green	Ped. 108 Golden Vine	Ped. 408 Green	2387	Arthur	103C/1 Hybrid
1914	16.5	19.8	13.7	16.0	13.7	16.0	19.1	15.3	16.2	.....	.....
1915	21.0	20.0	20.3	25.0	17.3	23.3	24.7	23.0	22.3	.....	.....
1916	7.7	8.8	4.9	6.3	5.7	5.3	6.0	7.7	6.0	.....	.....
1917	26 4	23.3	22.3	28.5	22.3	29.0	31.3	32.0	30.0	24.1	28.0
1918	33.9	35.7	27.3	39.7	35.0	43.3	45.3	28.7	32.0	35.3	36.0
1919	9.8	11.8	10.6	9.93	11.06	7.0	10.4	10.5	7.0	13.73	12.07
1920	19.5	22.2	23.8	18.5	23.1	17.2	19.7	18.2	17.2	23.4	22.10
Average for 7 years	19.1	20.2	19.0	20.6	18.4	20 2	22.4	19.3	18.7	.....	.....
Average for 6 years excluding 1916	21.0	22.1	21.3	22.9	20.5	22.6	25.1	21.3	20.8	.....	.....
Average for 4 years	.....	.....	.....	.....	.....	.....	.....	.....	.....	24.1	24.5

BREEDING WORK WITH PEAS

In addition to the pure line work, new varieties have been produced by crossing different types. At the present time several hundred selections from crosses in different stages of breeding work are being grown at the Ashland Station. Seed of some of these varieties is available in sufficient quantities to permit of variety tests, and preliminary field tests with farmers. Some of the objects sought for in breeding peas are (a) shortening the growing period of the Scotch and Green varieties; (b) producing varieties with shorter straw, (c) producing varieties with the pods in a cluster at the top of the vine, and (d) producing peas which are resistant to various diseases.

A lack of pure seed is one of the great drawbacks to development of the pea-growing industry in Wisconsin. A realization of this fact prompted the breeding work at the branch experiment stations with the primary object of purifying the Wisconsin standard varieties, such as the Scotch, Green, Marrowfat, and common yellow. At the present time pure strains of different varieties are available in considerable quantity and can be obtained by growers. Dealers in peas are anxious to get stock

FIG. 10.—DIFFERENCE IN GROWTH HABIT BETWEEN TWO SCOTCH TYPES

Arthur vine type of Scotch pea (right) and ordinary Scotch (left). The first is derived from a cross between Arthur and Scotch peas.

of this character; hence, farmers who will grow such grains are sure of better prices for their stock than for common, unpurified peas. The mixtures ordinarily found in peas are (1) black, or "horse" peas which have purple blossoms, (2) green peas in yellow varieties; (3) yellow peas in green varieties. Small seeds are undesirable in seed peas.

The breeding work has done one other important thing, that is, improving the producing power of the pure strains. A comparison of the yields of pedigree strains in 1911 with the unselected strains of the same season shows marked improvement in yield of selected strains.

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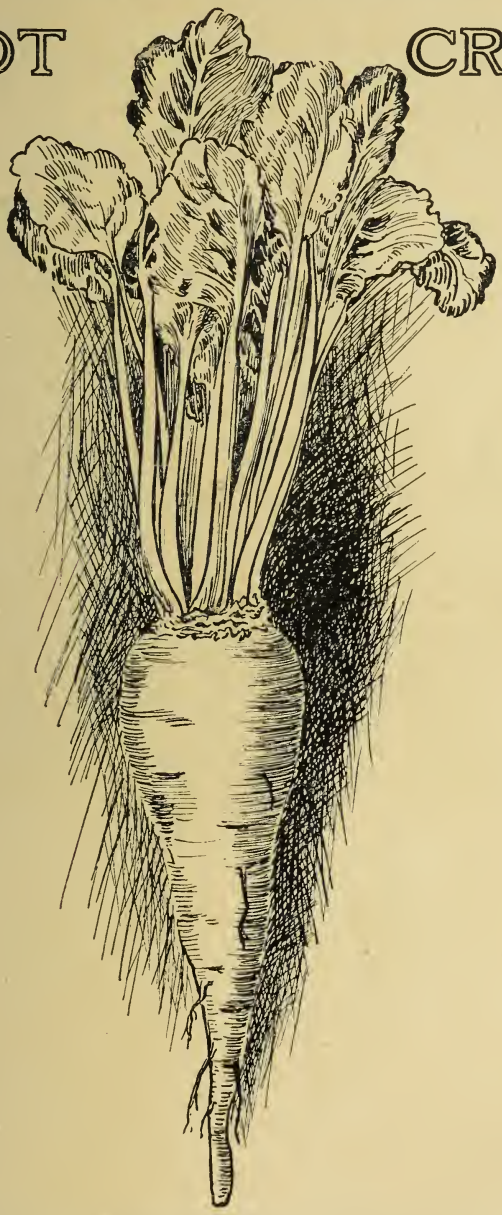
PROFITABLE ROOT CROPS



AGRICULTURAL EXPERIMENT STATION
OF THE UNIVERSITY OF WISCONSIN
MADISON

DIGEST

Root crops should be grown on many Wisconsin farms where livestock is kept. They supplement silage and grain feed and are a main source of winter succulence on small farms where only a few cows are kept or where the farmer is not financially able to build a silo. Page 3

Roots cost no more per ton than corn silage on the heavy soils in upper Wisconsin. At Ashland roots cost $4.06 per ton, corn silage $5.35 per ton, and at Conrath roots cost $2.52 per ton and corn silage $5.49 per ton. These are averages for three years. Page 4

Rutabagas cost less per ton to produce than any other class of root crops. This was proved by variety tests covering several years and made at Ashland, Superior, Conrath and Marshfield. Pages 5–11

Roots planted in drills 24 to 36 inches apart give best results. The land should be well manured and well fitted before planting. Pages 11–12

Plant roots from May 1 to June 30. Early planting gives best results. Rutabagas and turnips may be sown as a catch crop on new land as late as June 30 in upper Wisconsin and later in the lower part of the state. Page 13

Careful thinning is essential for big yields. Distances between plants may range from 8 inches for carrots to 12 inches for rutabagas. Page 14

Clean cultivation to keep down weeds and conserve soil moisture should be given root crops. Page 15

Store roots near where they are to be used for feeding. Root cellars may be built of stone, hollow tile, concrete or timbers covered with other material to prevent freezing. Well-covered pits built in the field may be of service temporarily. Pages 17–22

Bulletin 330 March, 1921

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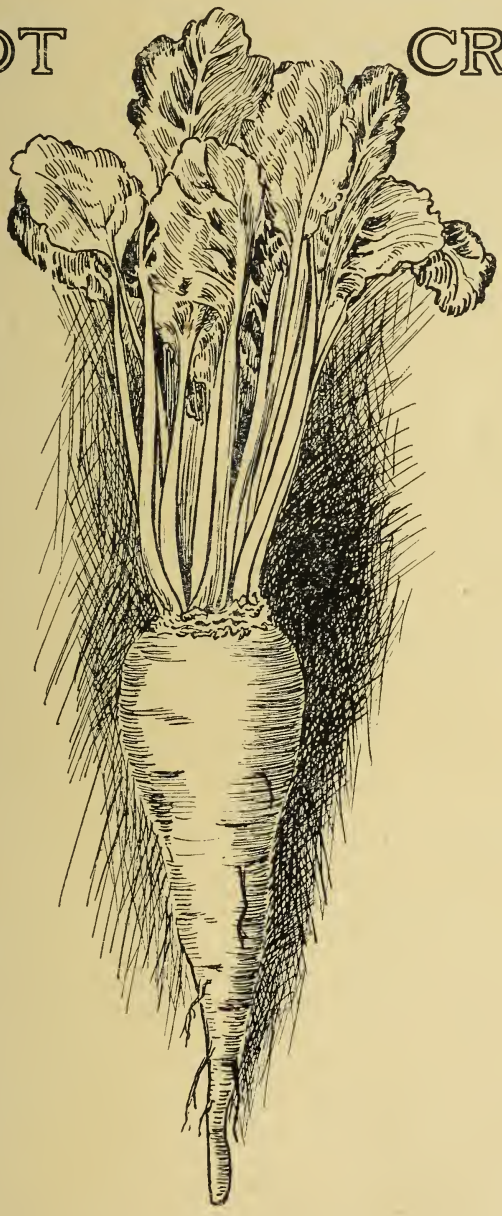

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Profitable Root Crops

E. J. Delwiche

ROOT crops should be grown more extensively in Wisconsin. Many sections of the upper part of the state are especially adapted to their culture. Root crops are of especial value on farms where there are no silos, as is often the case with new settlers' farms, or on farms where not enough livestock is kept to prevent the silage from spoiling. In sections of the state where corn will mature sufficiently for silage in the average season, corn silage usually furnishes succulent feed at considerably less expense than do roots. However, many experienced stockmen prefer to feed roots in addition to silage to such stock as dairy cows on official test or animals being fitted for shows. Roots may also be fed as a substitute for grain or other concentrates thus often reducing the cost of feed.

Roots are sometimes desirable to fill in the rotation as a cultivated crop, especially on certain heavy soils in northern Wisconsin which are not very well adapted to corn or potatoes. On such land root crops may take the place of other cultivated crops, at least in part, thus rounding out the rotation.

Roots an Economical Crop in Upper Wisconsin

While roots are commonly a more expensive feed than corn silage throughout the corn belt, they are economical in upper Wisconsin. Comparative costs of producing roots and corn silage have been worked out at the Ashland Branch Station and the Rusk County Demonstration Station at Conrath. At Ashland the experiments were made on Superior red clay, one of the heaviest types of soil found in northern Wisconsin. At Conrath the trials were made on Kennan silt loam which is typical of a great part of central Wisconsin. In this study a cost accounting

was kept including all labor from plowing to filling the silo, and slicing the roots before feeding. This test was made three years in succession—in 1918, 1919, and 1920. The cost of labor was high—$2.75 a day for man, and $2.75 for team labor for 1918 and 1919, and $.40 an hour for man and $.25 per team hour for 1920. The cost of slicing roots with gas engine and feed cutter was $.50 a ton. This amount was added to the cost per ton.

The average cost of a ton of rutabagas over three years at Ashland was $4.06 per ton and at Conrath $2.52. Corn silage cost $5.35 per ton at Ashland, and $5.49 at Conrath.

The yield of rutabagas per acre and cost of production per acre and per ton for ten years are given in Table I. The tests were made at Superior on the Douglas County Demonstration Station on red clay soil.

TABLE I.—YIELD AND COST OF PRODUCING RUTABAGAS AT DOUGLAS COUNTY DEMONSTRATION STATION 1909 TO 1919 INCLUSIVE (NO ROOTS WERE GROWN IN 1917)

Year	Yield in tons per acre	Cost per acre	Cost per ton
1909	8.04	$50.71	$6.31
1910	9.95	58.60	5.88
1911	26.79	39.10	1.42
1912	10.22	43.00	4.20
1913	7.01	47.72	6.80
1914	4.00	26.54	6.63
1915	16.00	32.27	2.01
1916	8.00	33.00	4.12
1918	13.50	46.12	3.41
1919	14.10	34.92	2.47
Average	11.76	41.20	4.32

ROOTS ARE EXCELLENT FEED FOR LIVESTOCK

The growing of rutabagas for human consumption differs only in minor details from the methods used in growing them for livestock. The digestible nutrients in different classes of roots in comparison with corn silage are given in Table II.

Profitable Root Crops

E. J. Delwiche

ROOT crops should be grown more extensively in Wisconsin. Many sections of the upper part of the state are especially adapted to their culture. Root crops are of especial value on farms where there are no silos, as is often the case with new settlers' farms, or on farms where not enough livestock is kept to prevent the silage from spoiling. In sections of the state where corn will mature sufficiently for silage in the average season, corn silage usually furnishes succulent feed at considerably less expense than do roots. However, many experienced stockmen prefer to feed roots in addition to silage to such stock as dairy cows on official test or animals being fitted for shows. Roots may also be fed as a substitute for grain or other concentrates thus often reducing the cost of feed.

Roots are sometimes desirable to fill in the rotation as a cultivated crop, especially on certain heavy soils in northern Wisconsin which are not very well adapted to corn or potatoes. On such land root crops may take the place of other cultivated crops, at least in part, thus rounding out the rotation.

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TABLE II.—DIGESTIBLE NUTRIENTS IN DIFFERENT CLASSES OF ROOTS AND CORN SILAGE.*

	Total dry matter in 100 lbs.	Digestible nutrients in 100 lbs.				Nutritive ratio
		Crude protein	Carbohydrates	Fat	Total	
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	1:
Artichokes	20.5	1 0	14.6	0.1	15.5	14.8
Mangels	9.4	0.8	6 4	0.1	7.4	8.2
Rutabagas	10.9	1.0	7.7	0.3	9.4	8.4
Turnips	9 5	1.0	6.0	0.2	7.4	6.4
Carrots	11.7	0.9	8.6	0.2	9.9	10.0
Sugar beets	16.4	1.2	12.6	0.1	14.0	10.7
Corn silage, well matured corn	26.3	1.1	15.0	0.7	17.7	15.1
Corn silage, immature corn	21.0	1.0	11.4	0.4	13.3	12.3
Corn silage from frosted corn	25.3	1.2	13.7	0.6	16.3	12.6

*Selected from "Feeds and Feeding" Henry and Morrison

The table shows that roots are rather low in total dry matter. Compared with silage made from fully matured corn, rutabagas contain only 53 per cent as much dry matter as the former. On the other hand, rutabagas contain 70 per cent as much dry matter as immature corn silage. Under conditions such as prevail at Ashland and Conrath, rutabagas can be grown more profitably than corn.

Experiments by different investigators show that the dry matter in roots is at least of equal value to the dry matter in corn silage and equal to the dry matter in concentrates. E. S. Savage of Cornell University concluded in addition that roots may be fed to the extent of replacing one-half of the dry matter in mill feeds, and that where roots can be grown for $4 per ton they can replace grain and other concentrates with profit when the latter costs $60 per ton.

RUTABAGAS ARE BEST FOR UPPER WISCONSIN

Variety tests with different roots have been made at Ashland, Superior, Conrath, Marshfield, and at Polar, Langlade County. The tests at Superior have been the most comprehensive from

the standpoints of number of years tried and the different classes of roots included in the trials. The leading varieties of mangels, rutabagas, stock carrots and turnips have been included in the tests. Only the most promising variety of each kind of roots was retained for four years; the others were dropped.

The soil on which the work at Superior was carried on is typical red clay, a type not especially adapted to corn; thus the

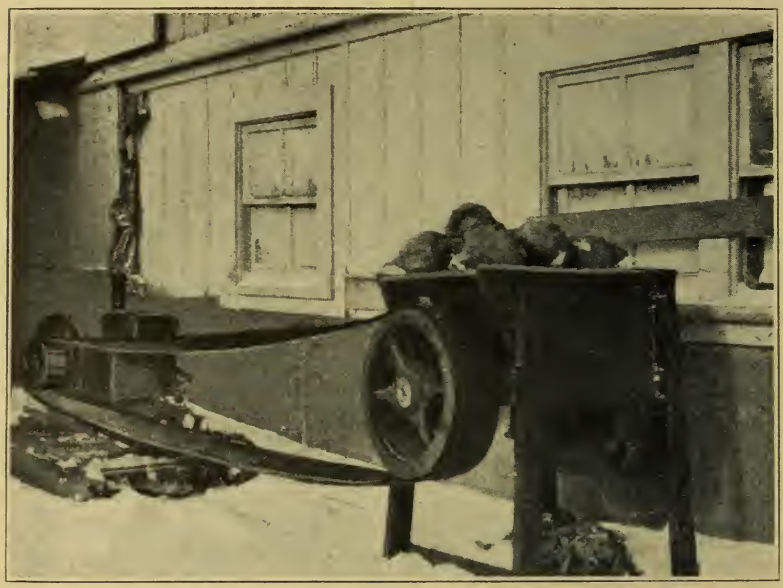


FIG. 1.—ROOT CUTTER RUN BY SMALL GAS ENGINE

The cost of slicing roots for feeding by this method is about 50 cents a ton.

need of a substitute cultivated crop in the rotation is obvious. The roots were planted on sod to which a dressing of 10 tons of manure per acre was applied after the land was plowed. The manure was thoroughly disked in. Planting was done from May 5 to May 25, depending on the season. The distance between rows was 36 inches. Rutabagas and turnips were thinned 10 to 12 inches apart, mangels and beets 8 to 10 inches, and stock carrots 7 to 9 inches. The test was begun in 1909 and carried through for four years with both rutabagas and turnips, and three years with stock carrots. Mangels and beets were dis-

carded after two years because of the high cost per ton to produce them. See Table II. The heavy clay soil on which the experiments were made is not adapted to beets, chiefly because it is difficult for them to get a stand on account of the baking of the soil.

FIG. 2.—ROOTS OF MANY KINDS

(1) Sugar beet (2) tankard mangel (3) mammoth red mangel (4) rutabaga (5) yellow globe mangel.

Table III studied in connection with Table II points clearly to the rutabaga as the root to grow on our heavy red clay soils. Results at Ashland, as given in Table IV, and the experience of farmers working under similar conditions, confirm this conclusion.

Rutabagas produce a stand more easily than mangels, require less seed, endure drought and wetness better, are easier to dig, do not freeze so readily in the fall, keep better and are equal at least in feeding value. Turnips have many of the good points of rutabagas, but they freeze more readily, do not keep so late in the winter, and are lower in total digestible nutrients.

TABLE III.—VARIETY TEST WITH ROOTS AT SUPERIOR

Year	Measure of crop value	Monarch rutabagas	Mastodon carrots	Giant feeding sugar beet	Mammoth red mangel	Yellow Belgian carrot	Golden tankard mangel	Yellow Aberdeen turnip
1909.....	Yield in tons per acre.....	8.04	5 9	7.12	6.19	3 23	5.22	5.85
	Cost per ton ...	$6.31	$8 59	$7.12	$8.19	$15.70	$9.71	$8.66
1910.....	Yield in tons per acre.....	9.95	3.05	6.81	5.57	4.96	4.47	5.82
	Cost per ton ...	$5.88	$19.21	$8.60	$10.52	$11.81	$13.10	$10.43
1911.....	Yield in tons per acre.....	26.79	12.08	Failure	Failure	Failure	Failure	28.49
	Cost per ton ...	$1.42	$3.05	Failure	Failure	Failure	Failure	$1.37
1912.....	Yield in tons per acre.....	10.22	.....	.....	.....	.....	.....	8.25
	Cost per ton ...	$4.20	.....	.....	.....	.....	.....	$5.21
Average.	Yield in tons per acre.....	13.75	7.91	6.96*	5.88*	4.09	4.84*	12.10
	Cost per ton ...	$4.48	$10.28	$7.86	$9.35	$13.75	$6.40	$6.41

*Two-year averge.

The test at Ashland was on red clay soil similar in type to that at Superior though not quite so heavy. Soil treatment, distance of planting, and thinning, were identical to the Superior experiment.

TABLE IV.—VARIETY TEST WITH ROOTS AT ASHLAND, 1913

Variety	Yield in tons per acre	Cost per acre
Monarch rutabaga.....	24 57	$1.74
Bangholm rutabagas.....	21.00	2.04
Mammoth long red mangel.....	17.49	2.46
Victoria carrot.....	14.06	3.05
Sugar beets.....	17.87	2.40
Mastodon carrot.....	10.65	4.03
Golden tankard mangel.....	21.37	2.01
Giant feeding sugar beet.....	14.4	2.98
Giant Eckendorf mangel.....	14.4	2.98

FIG. 3.—A 20-TON ROOT CROP

These plants were grown on north central Wisconsin loam soil.

TABLE V.—TESTS WITH VARIOUS ROOTS AT CONRATH STATION

Varieties	Tons yielded per acre	Year
Hursts monarch rutabaga*	35.0	1912
Yellow Aberdeen turnip	22.5	
Sugar beet	25 6	
Yellow globe mangel	8.0	
Imperial golden mangel	9.44	
Mammoth long red mangel	9 45	
Giant Eckendorf mangel	10.0	
Victoria carrot	20.4	
Mastodon carrot	14 5	
Giant feeding sugar beet	21.8	
Hursts monarch rutabaga	20.00	1917
Rutabagas	16.0	1918
Mangels	10 0	
Rutabagas	26.0	1919
Rutabagas	18 0	1920

*Five-year average for rutabagas was 23 tons

Three variety tests on representative loam soils were made in central Wisconsin. One was made on Chelsea loam soil in 1912 on a farm near Polar, Wisconsin. As a result of this trial the

FIG. 4.—SUPERIOR RED CLAY SOIL PRODUCES GOOD ROOT CROPS

Mangels and carrots in upper picture, rutabagas in lower.

farmer concluded that rutabagas were the best roots to grow, although the short type of mangel was very satisfactory.

A variety roots test was made at the demonstration station at Conrath in 1912. The soil there is well drained Kennan silt

loam. Table V gives yields in tons per acre. The Monarch variety of rutabaga gave the best yield per acre here as in the other tests reported. No cost accounting was kept.

The test at Marshfield was made in 1913 on Colby silt loam. Here, as in every other test mentioned, the Monarch variety of rutabaga gave the highest yield per acre. It was also the easiest to harvest and store.

TABLE VI.—TESTS WITH VARIOUS ROOT VARIETIES—MARSHFIELD BRANCH STATION, 1913

Varieties	Tons yielded per acre	Cost per ton
Monarch rutabaga	24.0	$2.08
Long red mangel	14.3	3.50
Golden tankard mangel	18.25	2.74
Sugar beet	17.5	2 86
Aberdeen turnip	12.25	4.08
Mastodon carrot	22.0	2.27

All these tests were made on representative loam and clay soils found in northern Wisconsin. They represent the general range of soils formed there except the lighter sandy types, and the clays and loams of calcareous nature. The tests were made under conditions prevailing over the greater part of the northern section of the state.

The rutabaga is the most profitable root to grow, as these experiments clearly indicate. The Monarch variety is especially recommended, because of its high yielding power, good keeping qualities, and ease of harvesting.

THE CULTURE OF ROOT CROPS

SOIL AND SOIL PREPARATION

Roots may be grown on any class of soil, provided it is properly manured and thoroughly cultivated. However, because corn grows better on the lighter soils, roots—as cultivated crops—should be grown more extensively on heavy soils. One of the advantages of growing root crops is to fill in the need of culti-

vated crops in the rotation. Carrots and rutabagas do better than mangels and beets on comparatively light soils. Rutabagas give best returns on rather strong soil, although tenacious clays are not desirable for the deep rooted varieties. Where the drainage is good, rutabagas give large yields on very heavy clays.

In preparing land for roots it is necessary to manure liberally for heavy yields. Root crops demand a soil rich in nitrogen, potash, and humus. The latter is of great value as a means of holding moisture in the soil. A clover sod plowed in the fall and given a dressing of from 8 to 12 loads of stable manure an acre is well suited for all root crops. The amount of manure to use depends on its quality and the character of the soil. Manure containing too much straw should be avoided, especially if applied late in the season, as it is likely to interfere with the cultivation of the crop.

The land should be plowed in the early fall to a good depth, and the manure applied evenly during the fall and winter months. It should be thoroughly disked as soon as the ground can be worked well in early spring. This disking may be done a week or more before planting. On sandy and loam soil the plowing may be left until spring, except in the case of tough sod. Coarse manure should not be used in spring unless it is well rotted. The object should be to have an abundant supply of humus and plant food in the soil.

Good drainage is absolutely necessary to produce large crops of roots. Heavy clays which hold moisture should be plowed with frequent open furrows in narrow lands and provision made for good outlets. Root crops never recover fully if checked by excessive moisture early in the season.

Roots require very thorough preparation of the ground before seeding. The soil should be worked to a depth of from 5 to 6 inches. The disc harrow is a good implement to prepare land for roots. All large clods must be broken and the soil made fine and mellow. After disking thoroughly, follow with a planker and a spike tooth harrow. The ground, as a rule, should be made as mellow as the proverbial onion bed. On sandy and loamy soils there is little danger of making the ground too fine, but with clay soil care should be taken not to pulverize too much for if heavy rains come before the plants are up, a crust is likely to form and prevent the plantlets from breaking through the

ground. Such soils should be thoroughly worked so as to distribute plant food, and to render them mellow and porous without creating undue fineness of tilth.

BEST TIME TO PLANT ROOTS

The time for planting roots varies with seasons, soils and localities. Mangels and carrots should be planted rather early. If the ground is in condition to get a good tilth, they should be planted as soon as danger from killing frost is over. For the northern half of the state this will be from May 5 to 25. A light frost after the plants are up will do little damage. The dates for planting rutabagas can be extended to June 5.

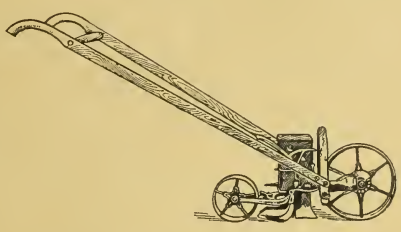


FIG. 5.—A GOOD HAND PLANTER

This drill is suitable for planting fields of five acres or less of root crops.

On heavy soils in a wet and cold spring there is a possibility of the seed rotting in the ground if planted very early. On warm, sandy soils there is little danger from this source. For catch crops, turnips and rutabagas may be sown as late as July 1. In dry seasons the earliest planting usually does best. It is better in any event to delay planting root crops for a few days or even weeks rather than to plant when the ground is wet, cold, and in poor working condition.

HOW TO PLANT ROOTS

Root crops may be planted by hand or with hand or horse seed drill. Planting by hand is a laborious method and is not practicable except for small patches.

Some types of grain drills can be set so as to drill root seeds very evenly, even rutabagas and turnips. The seed is placed in the proper seed boxes so as to sow at the right distance between the rows. With small seeds, such as rutabagas and turnips, sow as lightly as the machine will permit.

Broadcasting rutabagas is often practiced on land which does not admit of cultivation. Results are not nearly so sure as with

drilling, since cultivation to save moisture and kill weeds is impossible. On newly cleared brush land, rutabagas and turnips are often sown between the stumps without plowing. The ground is first harrowed with spring tooth or disk and the seed broadcasted as thinly as possible. This method should be used only where cultivation is impossible. If the ground is weedy or the season proves a dry one, only a light crop of inferior quality results.

DISTANCE BETWEEN ROWS

Rows may be from 18 to 36 inches apart. Where cultivation after planting is to be done by hand the distance should not exceed 24 inches, for a larger yield per acre will be secured than by planting at a greater distance between rows. For horse cultivation the rows must be straight and an even distance apart. About 33 inches is probably a safer width at which to plant. At this distance, with a perfect stand of roots 12 inches apart in a row and roots averaging four pounds each, the yield would be 31 tons per acre. With a stand of 70 per cent the yield would be over 21 tons per acre. These figures show that heavy yields are possible at 33 inches between rows provided the stand is good.

DEPTH OF PLANTING

The depth of planting is of considerable importance. On light soils mangels may be planted to 1 inch as maximum depth; ¾ of an inch is approximately the maximum depth for loam soils, and on heavy clays not over ½ inch. These depths are given on the basis that the seed bed is fairly moist and uniform in tilth. If the soil is very dry it may be necessary to plant deeper. Rutabagas should be covered about as deep as mangels, and carrots even less. As a rule, shallow planting gives the greatest percentage of germination provided the seeds are covered and in contact with moist soil.

PLANT GOOD SEED AND ENOUGH OF IT

Th amount of seed planted should be sufficient to give a good stand. It should be tested for germination, and if below 75 per cent should be rejected. It is better to be liberal with seed than to risk getting a poor stand. The following amounts of

seed per acre are advisable; Mangels, 3 to 4 pounds; carrots, 1 to 2 pounds; turnips and rutabagas 1 to 1½ pounds. These amounts are for roots planted in drills. Rutabagas should be sown somewhat thicker than turnips as the seed is larger.

Unless the seed is known to be of high quality and well distributed when sown, growers should use from 20 to 25 per cent more seed than the largest amount above given. The cost of seed is rather insignificant when compared with other items in raising roots; therefore, it pays to sow enough seed to insure a good stand.

CAREFUL THINNING ESSENTIAL TO LARGE YIELDS

As soon as the plants are well up and have made four or five true leaves, roots should be promptly thinned to the proper distance in the row. Lower yields result when thinning is delayed until the plants are too large. Before thinning it is a good plan to "bunch" with the hoe, that is, cut plants out leaving bunches to be thinned to one plant at the right distances. This bunching should be done carefully, since it determines the distances that will be left between plants. In thinning, leave only one plant in each place for if two or more are left together only small and inferior roots will develop. It is a good plan to go over the ground a second time two or three weeks after thinning and pull out all surplus plants. Leave only the most vigorous and thrifty plants even if doing so means that plants will be left in uneven distances apart in the rows.

Stock carrots should be thinned to 8 or 9 inches apart in the rows and mangels, rutabagas and turnips 10 to 12 inches. This applies to roots intended for stock feeding. When grown for market, rutabagas and turnips should be thinned about 8 inches apart in the rows. The distances given are on the basis of rows, 30 inches apart. If the rows are farther apart the distance between plants should be somewhat less, if the rows are closer the plants should be more widely separated. Proper thinning is essential to success in growing root crops.

ROOTS REQUIRE THOROUGH AFTER CULTIVATION

Frequent and thorough cultivation is necessary to grow crops of roots. Cultivation is needed to keep down weeds and to con-

serve moisture in the soil. As soon as the rows can be seen plainly the first cultivation should be given. Immediately after thinning cultivate again very thoroughly, being careful not to throw soil on or against the plants. Better roots are grown if the soil is drawn away from the roots in cultivation rather than toward them.

Cultivation should be repeated as often as necessary to maintain a flaky dust mulch, and keep down all the weeds. Cultivation should be shallow, except the first two times when it may be fairly deep. Once or twice during the season it will be necessary to go over the field with hoes in order to stir the soil and kill weeds between plants in the rows.

The styles of cultivators in use vary considerably. Figure 6 shows a good hand cultivator. It can be purchased as a combination with the drill shown in Figure 5. For horse cultivation, a walking cultivator or the ordinary sulky cultivator used for corn and potatoes may be used with good advantage to cultivate root crops fields. The special sugar beet cultivator is also well adapted to cultivate all roots. It is difficult to state definitely when cultivation should cease, because much depends on the season and the number of weed seeds in the ground. The aim should be to keep the ground free from weeds during the entire season. In ordinary seasons cultivation should continue at intervals until the middle of August.

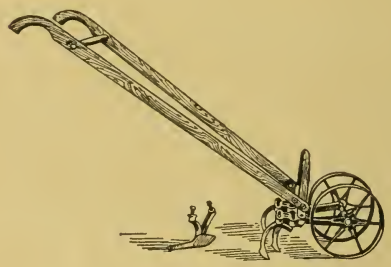


FIG. 6.—A GOOD TYPE OF HAND CULTIVATOR

This kind is especially effective for use with root crops. It may be had with a drill attachment such as is shown in figure 5.

HARVESTING THE ROOT CROP

Root crops, especially rutabagas and turnips, will stand light frosts without injury. Such varieties of mangels as grow largely out of the ground are likely to have their keeping qualities impaired if exposed to severe freezing. For most sections of northern Wisconsin, mangels should be harvested and covered about October 1. This applies also to stock carrots. Rutabagas

and turnips will stand more frost so they need not be pulled so early. They should be harvested before the middle of October, however.

In harvesting, from two to four rows usually are thrown in a windrow from which the roots are loaded on a wagon and hauled to a root cellar or pit. The roots are knocked together so as to shake the soil from them. Still more dirt is loosened in throwing the roots into the wagon. The unloading slide or chute should have a slatted bottom so the loose dirt can be sieved as the roots roll into the bin.

Topping may be done either before or after pulling. The quickest method to top roots, especially rutabagas, is with a sharp hoe. This is done before the roots are pulled. After topping, loosen the roots with a beet lifter, subsoiler, plow, or long-bladed hoe. After they are loosened the roots are picked up and thrown directly into the wagon box.

About 45 hours of man labor and 10 hours of team labor were used at Ashland in 1919 to harvest one acre of rutabagas and store them in the cellar. This was on red clay soil. The roots were topped with the hoe, loosened with a subsoiler, loaded directly into the wagon and hauled to the root cellar.

In harvesting carrots and mangels greater care must be taken not to bruise the roots than is necessary with rutabagas and turnips.

When the soil is dry enough to work well, the potato digger is an efficient machine for digging rutabagas and turnips. After the roots are topped, the digger is run under the rows so it will just cut the slender tap-root, without cutting in the fleshy part of the roots. The rutabagas are then picked up and hauled away.

STORAGE FOR ROOTS

The best place to store roots is in a root cellar near where they are to be used for feeding. Such a cellar may be a part of a barn or basement, or it may be built conveniently near the stock barn. In most places the root house can be built most economically of concrete. Ordinarily, lime or cement is the only material that has to be purchased. Stone, gravel and sand are usually available near most farms.

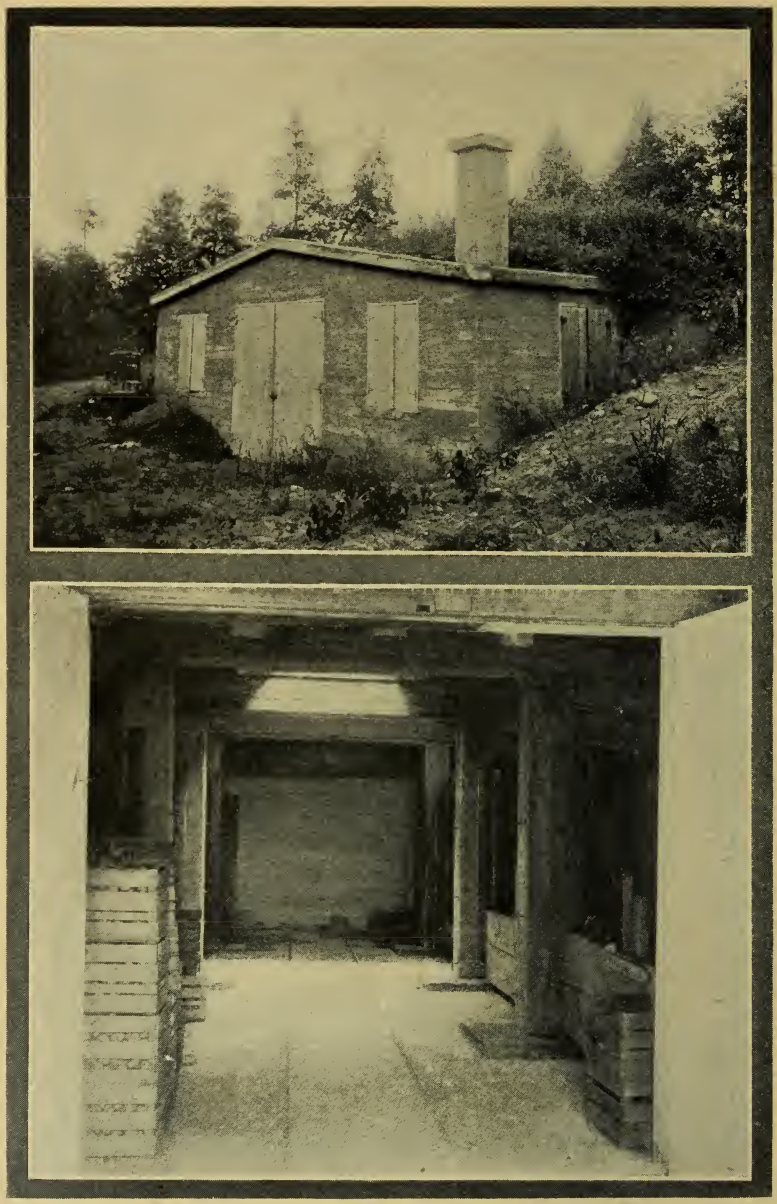


FIG. 7.—A WELL PROTECTED AND PERMANENT ROOT CELLAR

The entrance and outside view are shown in the upper picture while the inside view is shown in the lower. Note heavy pillars and girders to support roof. Built of reinforced concrete.

While the temperature in a root house should never fall to the freezing point, it must be low for the best results in keeping roots. Where possible, the root cellar should be built in a hillside so that only a small portion of the walls are directly exposed to the elements. Where convenient, a hay or straw shed should be built over the cellar as a protection against frost. An air space should be provided in all outside walls.

A cheap but useful root cellar may be built as shown in Figure 9. A shows the general plan of the frame work to support the roof. B shows a cross section of the structure. C gives a

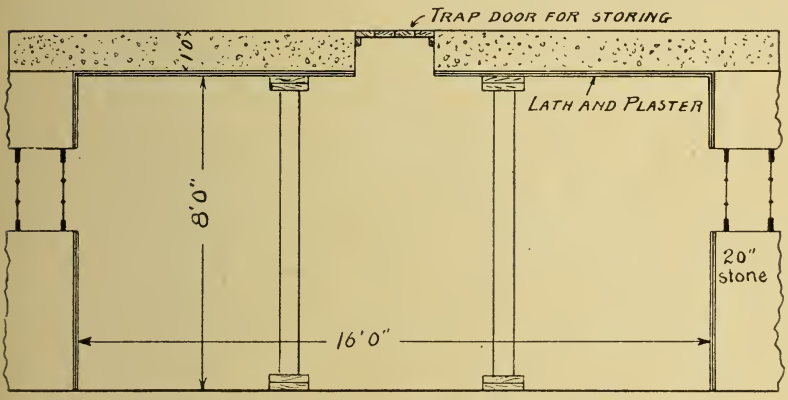
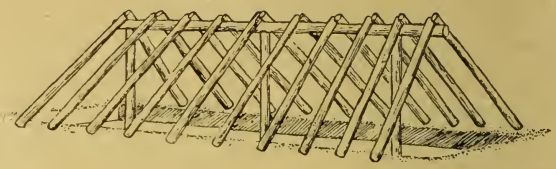


FIG. 8.—CROSS SECTION OF ROOT CELLAR BUILT UNDER DRIVEWAY

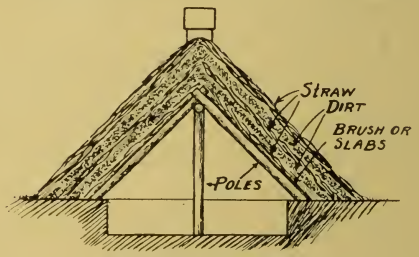
Note trap door used for unloading roots. Fig. 11 shows the outside view of this cellar.

general idea of the structure from the outside. The frame work is made of posts or poles, preferably of tamarack or cedar. These need not be of uniform size, but should be of sound wood. A layer of brush, old lumber, or slabs is laid at right angles with the rafters and on top of this a layer of straw or marsh hay. Then a layer of soil about 6 inches thick is put on and another layer of straw or marsh hay followed by a second layer of soil. Before winter, brush or corn stalks may be thrown on top of the whole to hold the snow. A double door should be provided. A well drained spot of land should be selected and provision made to keep out water from melting snow. Such a root house will do for a few years only.

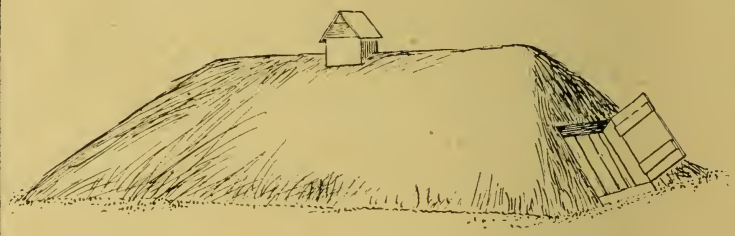
When no cellar is available, roots may be stored in pits. For fall and early winter feeding, they need not be covered to any



A. Frame built of tamarack or cedar poles.



B. Cross section showing covering.



C. Outside view—note double door.

FIG. 9.—A TEMPORARY ROOT HOUSE

great depth. The roots are heaped in a cone-shaped pile about 4 feet in diameter, on a bed of clean straw, and covered with a 2-inch layer of long straw. Clean rye straw is preferable. The straw at the peak of the pile is made to form a chimney—5 or 6 inches in diameter—for ventilation. Soil is thrown on the pile to a depth of 6 inches. The roots are piled as high as possible so as to shed water. When the roots are wanted for feeding, the whole pit is taken into the barn at once. For early winter feeding the layer of dirt should be thicker and a covering of straw or horse manure should be placed over the whole pile.

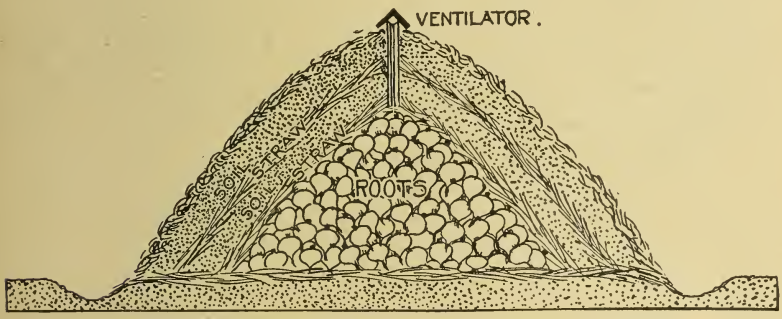


FIG. 10.—A WELL PROTECTED ROOT PIT TO REMAIN OVER WINTER

May be opened in winter when entire contents must be removed to barn to be kept there until all is fed.

Figure 10 illustrates a pit intended to remain over winter. It provides for two layers of straw and two layers of soil. A ventilator made of 4-inch boards is placed at the peak. When severe freezing weather sets in the ventilator is stuffed tightly with fine hay. Roots will keep without freezing even in the coldest winters in such a pit. The piles also may be made oblong instead of conical in shape, retaining the gable form. While pits do very well so far as keeping roots is concerned, it must be understood that they are but makeshifts at best. A root house which is accessible at all times is much more satisfactory and more economical in the end.

SPECIAL METHODS FOR POORLY DRAINED LANDS

On heavy clay soils where drainage is not good, root crops are likely to suffer in wet seasons. Where mangels and other crops were planted on low ridges they were found to grow faster and

to produce larger returns than if grown on level ground. A shovel plow as shown in Fig. 12 was used for ridging up the land. The plow is run very shallow and the field is marked at the desired distances before ridging up in order to insure straight rows. The ridging must be done when the ground is

FIG. 11.—OUTSIDE VIEW OF ROOT CELLAR BUILT UNDER DRIVEWAY

It extends inside the barn under the driveway where the trap door for unloading roots is located.

dry and well pulverized. The tops of the ridges are then made smooth with planker and smoothing harrow. A plank 9 feet long, 10 or 12 inches wide and 3 inches thick may be used for this purpose by attaching a chain to it for hitching.

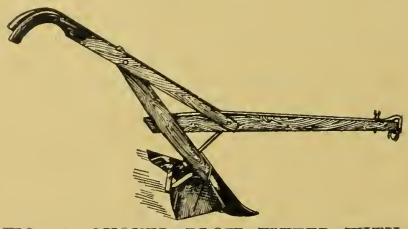


FIG. 12.—SHOVEL PLOW FITTED WITH WINGS

This is useful for ridging up land for certain types of root culture.

These ridges must be made smooth and level so as to enable the seed drill to sow the seed at a uniform depth and distance apart. All the troughs between ridges should be connected to cross ditches in which surface water is discharged and carried away. Cultivation during the growing season gradually reduces the height of the ridge until at the end of the season it is almost level. This method is recommended for level clay land having poor drainage.

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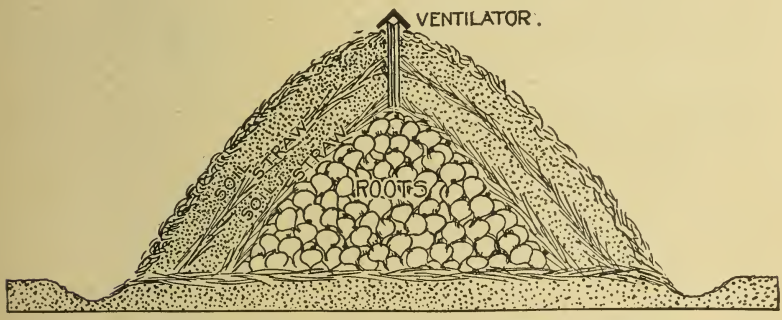

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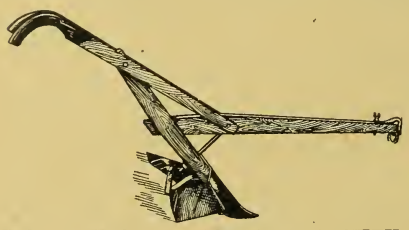

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Bulletin 331 April, 1921

Potato Scab

AGRICULTURAL EXPERIMENT STATION
OF THE UNIVERSITY OF WISCONSIN
MADISON

DIGEST

Potato scab is widespread in Wisconsin. It injures the appearance of potatoes for the table and reduces the quality of seed stock.
Pages 3–5

Corrosive sublimate seed treatment is one of the important ways of controlling potato scab. The tubers selected for seed should be soaked in a 1–1000 solution for 1½ hours while dormant and before cutting. Pages 6–7 and 10–19

Formaldehyde seed treatment is also used with some success.
Page 7

Other helps in scab control are the selection of scab-free seed, rotation of crops, selection of scab-free soil, and absence of heavy applications of lime, ashes, or fresh manure just previous to planting.
Pages 8–10 and 22–24

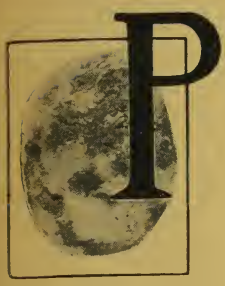
Disinfection experiments form the basis for the directions regarding scab control; see inside back cover and Pages 10–19

Corrosive sublimate loses strength when used for treating successive lots of potatoes. The strength should be maintained by adding ¼ to ½ ounce of the chemical after every 4 bushels treated.
Pages 20–22

Rural New Yorker is the freest from scab of all standard Wisconsin varieties. The varieties used, named in order of increasing scabbiness, are: Burbank, Green Mountain, Early Ohio, Triumph, and Irish Cobbler. Pages 25–26

Potato Scab

J. W. Brann and R. E. Vaughan



POTATO seed disinfection is one of the most effective and practical means of reducing scab. Its object is to kill the scab organisms on the surface of the tubers and thus prevent infection of the soil and of the following crop. This is especially true where the soil is free or relatively free from the disease germs.

In Wisconsin, as in most other northern potato states, scab is the most important disease with which the potato grower has to contend. The loss from this disease is difficult to estimate but considerable sorting for scab is necessary each season at all loading stations and on many farms in some localities. The value of the crop, either for table or seed stock, may often be directly reduced because of the unsightly appearance of the scabby tubers.

Wisconsin is producing a large amount of seed potatoes each year. Farmers raising this stock are especially concerned with scab because it reduces the production of tubers of high quality. Sections of the state recently opened to farming have little or no scab, but all growers throughout the state and especially those in the older potato sections must practice the best methods of seed selection, culture, and disease control in order to maintain the standards for table and seed stock.

Appearance of Scab

Diseased tubers show roughened and corked areas ranging from small spots to a general infection of the entire surface. The disease appears either as a raised surface or a slightly depressed area. Other types of injury are often confused with the true scab.

Deep scab, characterized by deep irregular corked areas, is no doubt associated with injury by wire worms, white grubs, mites, or thousand legged worms. It is generally supposed that these insects prefer to enter at the diseased areas.

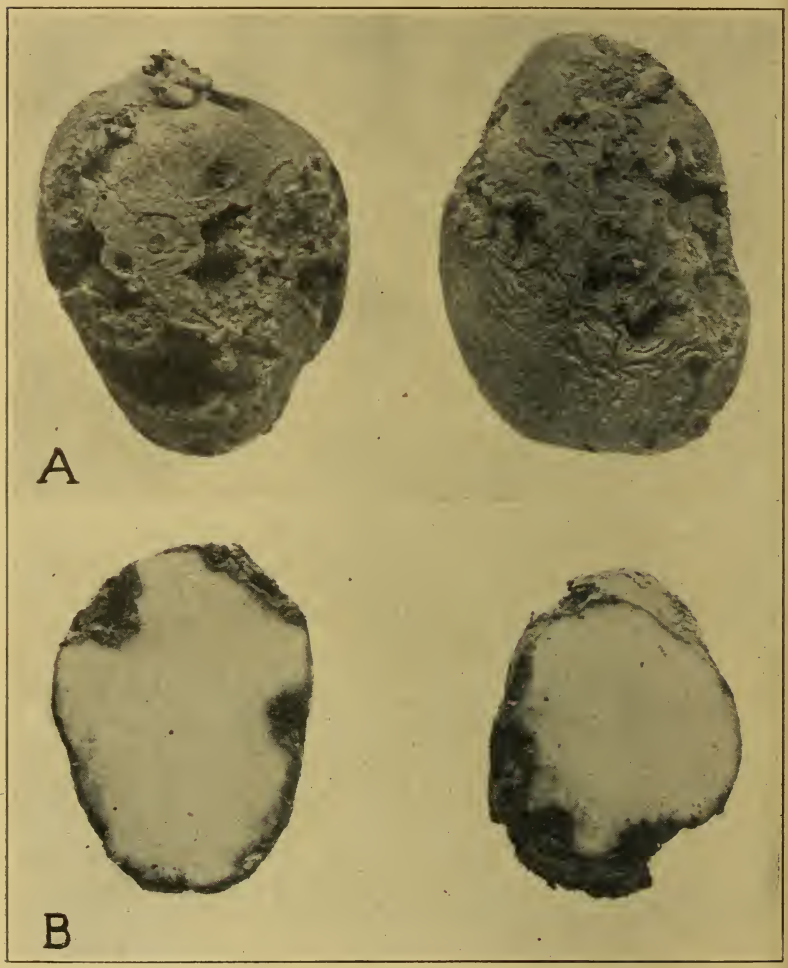


FIG. 1.—POTATO SCAB INJURES THE APPEARANCE AND QUALITY OF TUBERS

A—Deep scab increased by insect attack.
B—Cross sections of badly scabbed tubers. Wire worms, white grubs, and larvae of other insects often feed on potatoes injured by scab.

A condition quite similar to scab appears to be induced when the growing potato comes in contact with roots, stones, or other obstructions to normal growth.

A checked or corrugated surface much like scab may be caused by soil conditions and reactions resulting from application of chemicals, such as lime and ashes.

Enlarged lenticels, enlarged openings in the skin, which assume a corky appearance in older stages, are sometimes conspicuous on the Early Ohio and Triumph varieties. This condition has been observed on potatoes grown in wet soil or soil in which the temperature is abnormally high. It is not usually very serious.

FIG. 2.—ENLARGED LENTICELS

This appearance is most noticeable on the Triumph variety especially when grown on wet soil or at high temperature. It is often confused with scab.

CAUSE AND SPREAD OF POTATO SCAB

Potato scab is caused by an organism which, if once introduced into the soil, will live there for many years. On freshly dug scabbed tubers, one can see a delicate white growth which consists of countless scab germs. The disease is spread by planting

affected potatoes or those which have been in contact with scabbed seed.

Before the scab organism was discovered, the disease was attributed to any of these causes: too much moisture, heavy or rich soil, too much manure, excessive amounts of lime or ashes, and insects. Some of these may influence the development of scab but do not directly cause it.

CONTROL MEASURES

Corrosive Sublimate

Corrosive sublimate, 4 ounces to 30 gallons of water, has proved the best disinfectant for controlling potato scab under Wisconsin conditions. It is also the best control for Rhizoctonia and black leg. Since the chemical dissolves slowly in cold water, it should first be stirred into about a gallon of hot water.

The strength of the corrosive sublimate solution can best be maintained by adding ½ ounce for every 4 bushels of seed potatoes treated and keeping the volume of water constant. This additional amount is based on the 1½ to 2 hour treatment. If a shorter treatment is given, a correspondingly smaller amount of chemical should be added. For example, if 4 bushels are soaked 30 minutes, add ⅛ ounce of corrosive sublimate. For convenience have the corrosive sublimate in a stock solution, strength 1 ounce to 1 quart of water, made up in fruit jars or stone crocks.

Treat only sound, uncut tubers before the sprouts have started. Dry the tubers at once after treatment to prevent continued action of the chemical. In case of damp, slow-drying weather the tubers should be rinsed with clean water immediately after treatment. Keep in clean crates or sacks in half light for 10 days to two weeks before planting. This prevents reinfection and allows strong sprouts to start. Do not place the potatoes in direct sunlight because they will get too hot and develop black heart.

Barrels, or wood or cement tanks are frequently used in treating potatoes. The tubers may be handled loose or in crates or sacks. If sacks are used they should first be washed and disinfected; this prevents weakening of the disinfectant.

Galvanized tanks may also be used if the interior is coated with asphaltum paint.

Cautions. Corrosive sublimate is a deadly poison if taken internally; therefore, be very careful to keep it away from young children and all farm stock. Avoid over treatment either by too strong a solution or too long a time, as the eyes of the potato may be injured and germination retarded. Do not use treated potatoes for food.

FORMALDEHYDE[1]

Formaldehyde is sometimes used in treating potatoes. The standard strength is 1 pint to 30 gallons of water. The time of treatment usually is two hours. In these experiments a 30 minute treatment with corrosive sublimate was as satisfactory as two hours in formaldehyde.

Formaldehyde has been widely used for treating potatoes. Leading potato growers, however, found from long experience that it is not entirely satisfactory in controlling scab under Wisconsin conditions. Comparative trials of various methods and practices were made in order to determine the best recommendations for Wisconsin growers. As a result greater emphasis is now being placed on the use of corrosive sublimate.

SELECT SCAB-FREE TUBERS FOR SEED

The greater the amount of scab on the seed, the greater will be the number of scab germs introduced into the soil, and the greater the amount of scab on the crop. The use of "leftover" and warehouse seconds is strongly discouraged.

PRACTICE CROP ROTATION

The best growers have demonstrated that it is not advisable to grow potatoes on any given field oftener than every third year. A rotation with grain and clover is desirable where a part of the cultivated crop may be corn. The plowing under of a crop of clover or fall rye before planting potatoes is a

[1] The use of hot formaldehyde 118° to 122°F. has recently been recommended in Iowa by Melhus and Gilman. In this method formaldehyde is used at the strength of 1 pint to 15 gallons of water. The potatoes are soaked 3 minutes, drained, and covered for 1 hour.

practice to be highly commended from the standpoint of maintaining the fertility and good physical condition of the soil and in the control of scab.

SELECT SCAB-FREE SOIL

Soils in different sections of the state, on different farms, and even in different fields of the same farm vary in the amount of scab organisms present. In general, the older sections and

FIG. 3.—BARRELS FOR TREATMENT

Barrels set upon a platform make good containers when a few bushels of potatoes are to be treated. Potatoes should be treated loose. The solution can be drawn off after treatment and the potatoes easily emptied and spread to dry.

fields long used for potatoes will have the most scab. A farm plan will greatly assist in locating fields where potatoes should or should not be planted.

AVOID HEAVY APPLICATIONS OF LIME, WOOD ASHES, OR MANURES JUST PREVIOUS TO PLANTING

If the soil is too acid and needs lime, it should be applied *after* rather than *before* the potato crop. Good results have been secured by applying manures to the clover field the year previous to using it for potatoes.

AVOID FEEDING UNCOOKED SCABBED POTATOES TO STOCK

Experiments have shown that the scab organism may pass through the digestive tracts of animals without losing its power to produce the disease.

FIG. 4.—A CEMENT TREATING TANK

Potatoes are conveniently handled in crates. A cement tank with a central partition may also be used in preparing solutions of copper sulphate and milk of lime for making bordeaux mixture. Compare front page and figure 3 for different containers.

DISINFECTION EXPERIMENTS

Experiments of 1916–1917. The object of the experiments was to compare corrosive sublimate and formaldehyde in the control of scab when both clean and scabbed seed were used.

The results of extensive work done during the seasons of 1916 and 1917 at the Wisconsin Experiment Station, Madison, are presented in Tables I and II. Further work was done from 1918 to 1920 in Waushara County, Barron County, and at the Wisconsin Branch Station, Spooner.

In these plots there were 143 units or treatments, of which 119 were devoted to the Rural New Yorker and Green Mountain—the two leading standard late varieties of Wisconsin. In-

cluded in the remaining 24 units were the Burbank (late variety), Irish Cobbler, Triumph, Early Ohio, and Early Rose (early varieties). The average number of plants in each unit or treatment was 50. In the plots there was a total of 23 controls planted to clean seed and 13 controls planted to scabbed seed. Clean seed and scabbed seed were used both in treated and untreated units.

The potatoes in all experiments were selected with care as to uniformity in size, type, and quality. In units where scabbed seed was used, stock with uniform infection was selected.

TABLE I.—AVERAGE OF RESULTS, SEED POTATO DISINFECTION AT EXPERIMENT STATION PLOTS—1916 AND 1917

Rural New Yorker variety

	Treatment	No. of units	Per cent scab
Clean seed	Corrosive sublimate	14	3.5
	Formaldehyde	4	10.0
	Untreated	8	20.0
Scabbed seed	Corrosive sublimate	12	11.0
	Formaldehyde	5	20 0
	Untreated	6	52.5

Corrosive sublimate and formaldehyde were used as disinfectants. The corrosive sublimate was used at a strength of 4 ounces to 30 gallons of water (1 to 1000), and potatoes were treated 1½ hours. Formaldehyde (40% solution) was used at a strength of 1 pint to 30 gallons of water, and potatoes were treated 2 hours. The water was kept at about 16°C. (60°F.) throughout all experiments. The potatoes were dried immediately after treatment. They were planted by hand 4 to 6 inches deep in rows 3 feet apart, with plants 16 inches apart in the row. Neither the appearance of the tubers nor the stand indicated any injury as a result of the treatments.

The soil in these plots was in part a medium silt loam and in part a medium clay loam. Both spring plowing and fall plowing were tried resulting in practically no difference in the amount of scab on the crop.

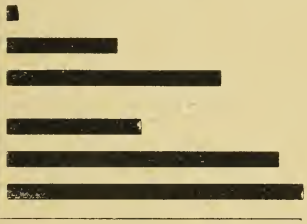
The season of 1916 was hot and dry. It was observed that under these conditions the development of scab throughout the state was rather pronounced. The seasons of 1917 and 1918 were fairly normal in both temperature and moisture.

The results obtained from seed disinfection are summarized in graphic form as averages of the various treatments on all plots devoted primarily to the Rural New Yorker variety. Comparable results were obtained with the Green Mountain and Burbank varieties.

TABLE II —AVERAGE RESULTS, SEED POTATO DISINFECTION AT EXPERIMENT STATION PLOTS—1916 AND 1917

Irish Cobbler, Early Ohio, Triumph, and Early Rose (early varieties)

	Treatment	No. of units	Per cent scab
Clean seed..	Corrosive sublimate	3	2.5
	Formaldehyde.....	1	23.5
	Untreated..... ...	8	45.5
Scabbed seed..	Corrosive sublimate	3	28.5
	Formaldehyde.....	1	56.5
	Untreated.....	5	61.0



The results indicated by the percentage of scab on the product from treated and untreated seed, both clean and scabbed, show that corrosive sublimate is more effective than formaldehyde in the control of potato scab. Formaldehyde, however, reduced the scab considerably.

The product from treated scabbed seed showed more scab than that from treated clean seed. Possibly some of the germs adhering to the irregular scabbed areas resisted treatment, or, on the other hand, they may have been protected by air bubbles, which are more likely to form on scabbed seed than on clean seed immersed in a liquid.

The product from untreated scabbed seed showed a higher precentage of scab than that from clean seed controls (untreated). This is reasonable, since scabbed seed supposedly has a much larger number of germs on its surface than the

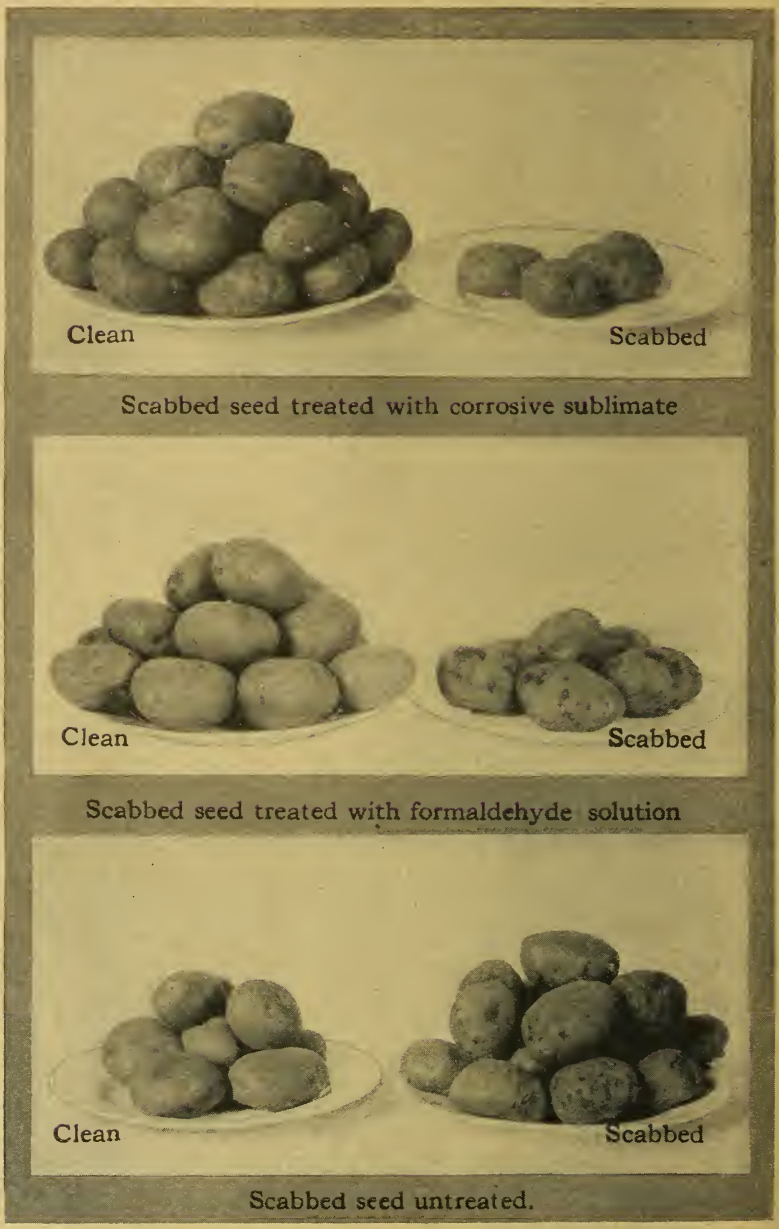


FIG. 5.—COMPARATIVE RESULTS OF 1917 EXPERIMENTS WITH SCABBED SEED

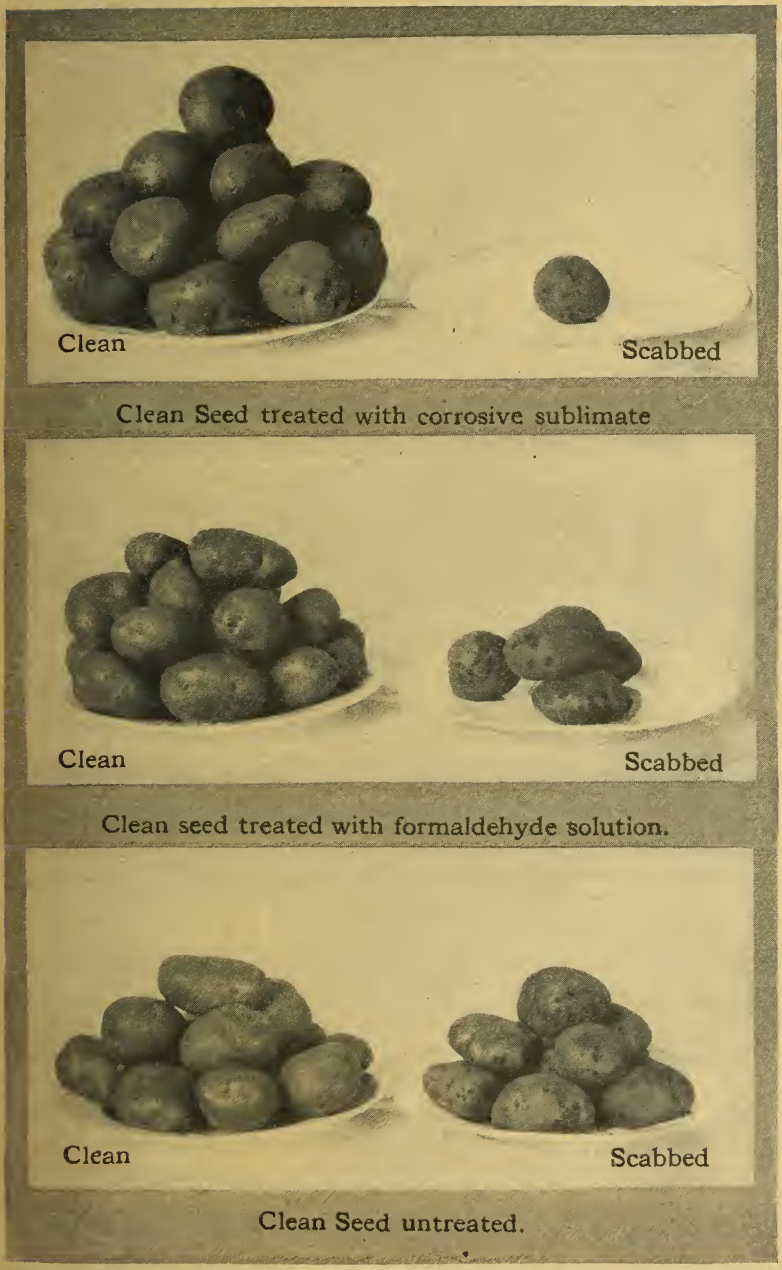


FIG. 6.—COMPARATIVE RESULTS OF 1917 EXPERIMENTS WITH CLEAN SEED

apparently clean seed. Since in this way more germs are introduced into the soil, it is expected that a higher percentage of scab will result when scabbed seed is used.

The tuber surface infection in the product from untreated scabbed seed was very much higher than that from untreated clean seed. The percentage of scab given, therefore, is not a true indication of the relative amount of infection of tubers, since equal consideration was given to a tuber having only one scabbed spot and one with a heavy surface infection.

The results show clearly the value of seed disinfection and also that the disease may be increased by planting scabbed seed stock. It is recommended, therefore, that growers select seed as free from scab as possible, whether or not it is to be treated.

Experiments of 1918. The objects of these experiments were: (1) to compare corrosive sublimate with formaldehyde in the control of scab, whether or not the tubers treated were previously soaked in water, and (2) to determine the effect of these chemicals on the control of scab when tubers were subjected to treatment for a duration of ½, 1, 1½, and 2 hours, respectively.

Corrosive sublimate at a strength of 4 ounces to 30 gallons water, and formaldehyde 1 pint to 30 gallons water, were used. The seed used was in part badly scabbed and in part relatively free from scab.

The soil in the Waushara County plot was a medium dark sandy loam, very uniform in texture. The main field in which the plot was located had been planted to potatoes in 1911 and again in 1914. As indicated by the untreated units, scab germs, no doubt, were present to some extent in the soil. The Late Ohio was used in all the units of the plot.

The results of these experiments indicate that the 1½ hour to 2 hour treatment in corrosive sublimate is more effective in scab control than the ½ hour treatment. However, the shorter treatment may be used if treatment must be delayed.

Seed soaked in water previous to treatment with corrosive sublimate gave a product that had less scab than the product from unsoaked seed. This appears to indicate either that water had some beneficial influence by washing off some of the scab organisms or in soaking up the tissue about the scab spots

so that it would be more readily penetrated by the disinfectants.

TABLE III.—SEED POTATO DISINFECTION FOR DIFFERENT LENGTHS OF TIME—LATE OHIO VARIETY, WAUSHARA COUNTY, 1918

Treatment	Time	Per cent scab
Corrosive sublimate	*Hours*	
Potatoes not soaked	½	25.5
Soaked 24 hrs. in water	½	17.0
Potatoes not soaked	1	7.5
Soaked 24 hours in water	1	4.5
Potatoes not soaked	1½	7.0
Soaked 24 hrs. in water	1½	10.0
Potatoes not soaked	2	13.5
Soaked 24 hrs. in water	2	2.0
Untreated		
Potatoes not soaked		64.0
Soaked 24 hrs. in water		65.0
Corrosive sublimate (selected seed, clean)	1½	5.5
Formaldehyde (selected seed, clean)	1½	20.5
Untreated (selected seed, clean)		55.0

The average of results shows that formaldehyde is not as effective as corrosive sublimate in the control of scab. This is shown clearly in the units where scabbed seed was used and confirms the reports received from the leading growers of the Wisconsin Potato Growers' Association.

Experiments of 1919. The objects of the experiments were: (1) to compare corrosive sublimate with formaldehyde solution (both hot and cold) in the control of potato scab, and (2) to determine the effect of these chemicals in the control when tubers were treated ½, 1, 1½, and 2 hours, respectively.

Corrosive sublimate was used at the strength of 4 ounces to 30 gallons water, and formaldehyde at 1 pint to 15 gallons water in hot solution and 1 pint to 30 gallons water in cold solution. Both scabbed and relatively clean seed were selected

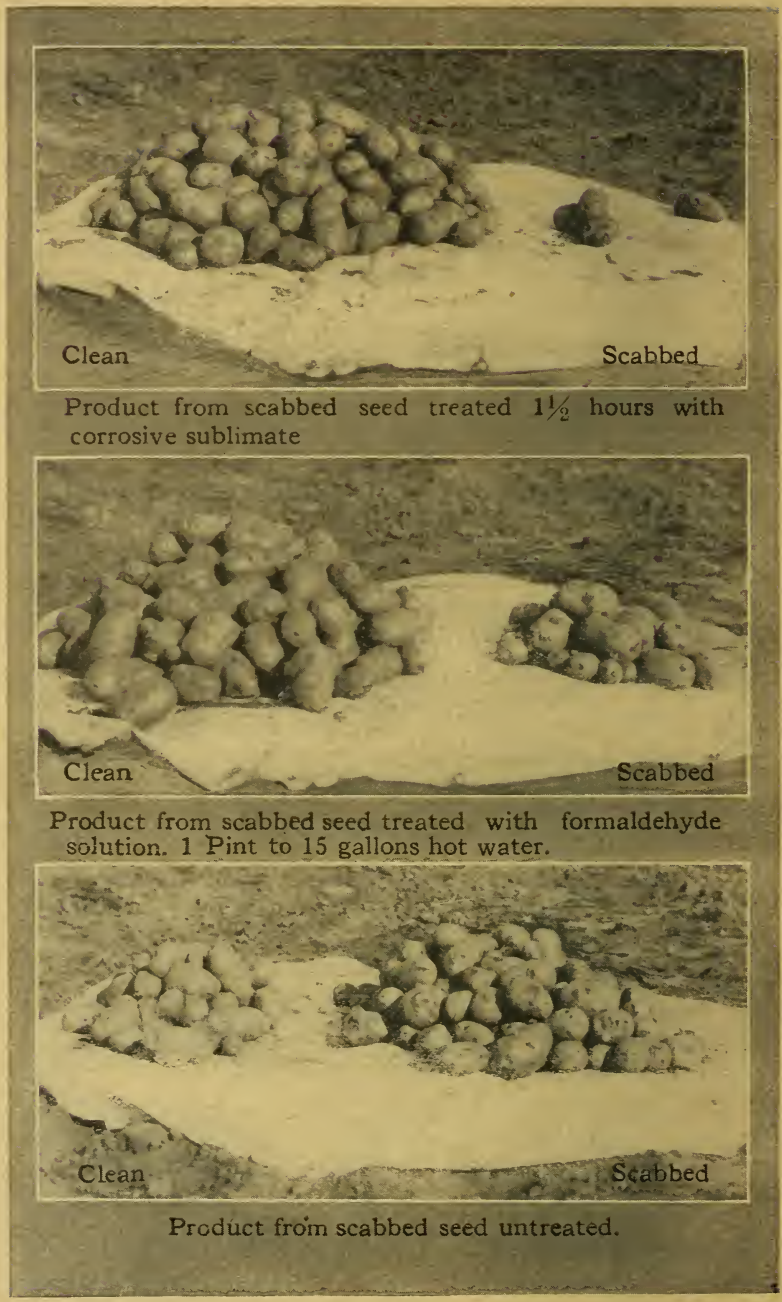


FIG. 7.—YIELD OF THREE 50 HILL UNITS SORTED FOR SCAB. EXPERIMENTS OF 1919

with care. Potatoes of the Late Ohio variety were selected from the same bin for both plots.

The soil in the Waushara County plot was a medium sandy loam of a very uniform texture. The soil in the Barron County plot was a medium clay loam of relatively uniform texture. Both soils had been cropped several times to potatoes, in a three-year system of rotation.

The plots at each place consisted of 25 rows (units) each containing 65 hills.

TABLE IV.—RESULTS OF SEED POTATO DISINFECTION—WAUSHARA COUNTY, 1919

Condition of seed	Treatment	Time	No. of units	Per cent of scab
		Hours		
Relatively clean.....	Corrosive sublimat	2	3	5.5
"	Untreated (control)	0	3	34.5
Scabbed....	Corrosive sublima'	½	1	15.0
"	"	1	1	11.0
"	"	1½	1	7.0
"	"	2	1	1.5
Scabbed.....	Formalde-hyde(cold 16°C. 61°F	½	1	44.0
"	"	1	1	37.0
"	"	1½	1	26.0
"	"	2	1	30.5
		Minutes		
Scabbed.....	Formalde-hyde, 54°C 129°F.. ..	1	1	32.5
"	"	2	1	20.5
"	"	3	1	19.0
"	50°C. 122°F.	4	1	24.0
"	50°C 122°F.	5	1	24.0
Scabbed.....	Untreated (control)..	0	6	63 0

Corrosive sublimate was more effective than formaldehyde (cold or hot solution) in the control of potato scab. This is shown clearly in the units where scabbed seed was used. Hot formaldehyde was more effective than cold formaldehyde and less effective than corrosive sublimate.

The half-hour treatment in corrosive sublimate was not as effective as the longer treatments. This method is not recommended except where seed is especially clean or in cases where treatment has been delayed until the sprouts have started. The results, however, indicate that this treatment is as effective as the longer treatments with formaldehyde (cold solution).

FIG. 8.—DON'T OVER-TREAT

A—Treated for 12 hours.
B—Section of injured tuber. Tubers treated when dormant are little subject to injury. If possible, treat potatoes from 10 days to two weeks or more before planting.

The percentage of scab decreased with the increase in the time of treatment, although there were some variations conflicting with what might have been expected. Any slight variations may be attributed to variable amounts of the scab organism in the soil.

The results of the experiments carried on in Barron County confirm in general those obtained in Waushara County.

Experiments of 1920. The objects of these experiments were: (1) to repeat the trials of corrosive sublimate in comparison with cold and hot formaldehyde, (2) to test the value of copper sulphate and inoculated sulphur, and (3) to determine the value of selecting seed apparently free from scab in the control of the disease.

The results at the end of the season showed that where the seed tubers had been treated with corrosive sublimate, the scab infection ranged from slight to medium in amount, with no cases of bad scab that would seriously disqualify for the

commercial market. The scab infection where formaldehyde has been used on the seed was somewhat more severe than with the corrosive sublimate treatment. There was practically no difference between the hot and cold formaldehyde. Where inoculated sulphur was harrowed into the soil at the time plants were coming through the ground, there was practically no difference between the treated and untreated plots. The copper sulphate treatment did not show sufficiently definite results so that safe conclusions could be drawn.

The control of scab by selecting apparently scab-free seed is a practice that can be recommended. The number of tubers that showed scab spots was greater than in many of the treated plots, but the extent of scab infection on the field run of the crop was distinctly less than where unselected seed tubers were planted. Furthermore, the result from such seed selection in the control of black scurf (Rhizoctonia) is much more important than with scab. Seed selection and treatment, therefore, are farm practices that can be most highly commended for the control of black scurf and scab.

Effect of Treating Successive Quantities of Potatoes In the Same Solution

In connection with the 1917 Madison experiments, 32 units were devoted to treating successive amounts of potatoes in the same solution of corrosive sublimate. Approximately ½ peck lots were used. Each lot was treated 1½ hours. One pint samples of the original solution and of the solution after each of the four successive treatments were taken for chemical examination. Analysis of the strength of each solution was made by the Division of Feed and Fertilizer Inspection, Wisconsin State Department of Agriculture. The results of analyses showed that the corrosive sublimate decreased in strength with each succeeding treatment. Since this was the case, it was expected that more scab would be present on the potatoes receiving later treatment. That this is true is shown in Tables V and VI.

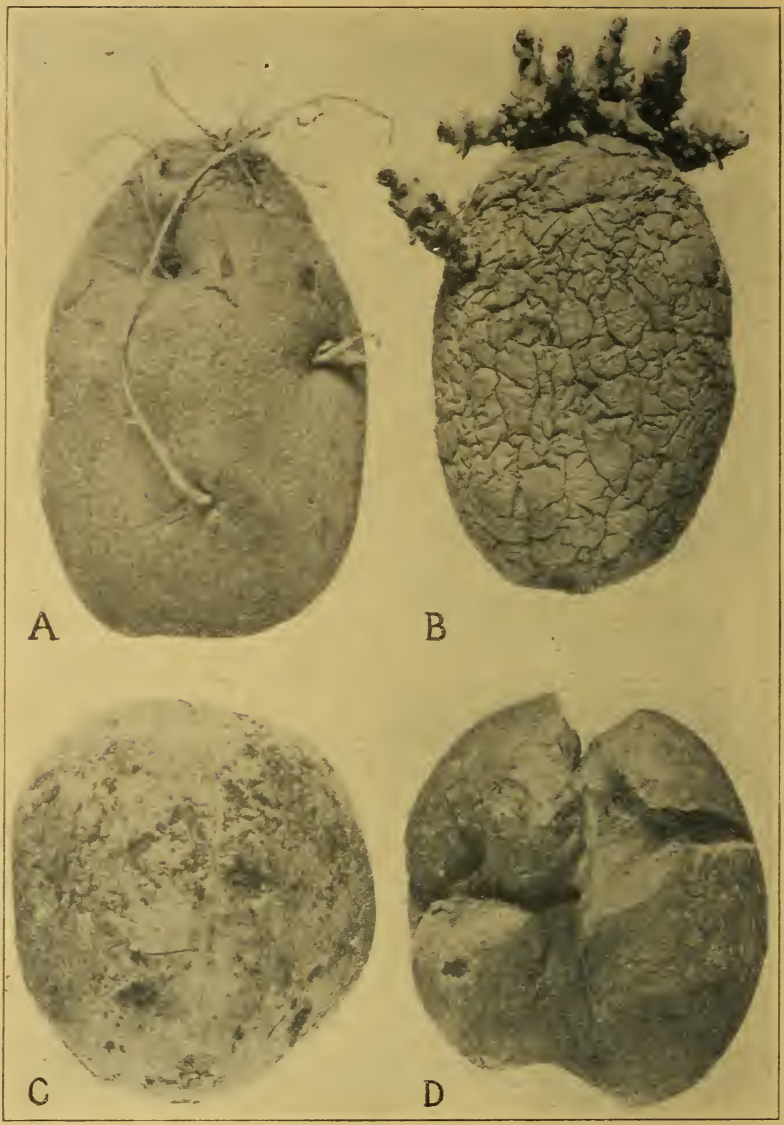


FIG. 9.—IT DOES NOT PAY TO PLANT OR TREAT INFERIOR SEED STOCK

A—Spindle sprouts indicate low vitality.
B—Excessively shriveled tuber indicates vitality lost through storage at too high temperature.
C—Black scurf or Rhizoctonia.
D—Growth cracks.

TABLE V.—RESULTS OF TREATING FOUR SUCCESSIVE AMOUNTS OF POTATOES IN THE SAME SOLUTION OF CORROSIVE SUBLIMATE—RURAL NEW YORKER VARIETY[1]

Number of treatment and condition of seed	Per cent scab			Average per cent scab	
	Exp. 1	Exp. 2	Exp. 3	Exp. 1, 2, 3	
1 clean	1.5	3.0	2.5	2.5	
1 scabbed	14.5	7.0	.....	10.5	
2 clean	5.5	7.0	2.0	4.5	
2 scabbed	17.5	7.5	.....	12.5	
3 clean	5.0	4.5	2.0	4.0	
3 scabbed	16.0	12 0	.....	14.0	
4 clean	5.0	4.5	8.0	6.0	
4 scabbed	23.0	14.5	.....	18.5	
Untreated					
Clean	15.0	11.5	19.0	15.0	
Scabbed	46.5	43 0	.....	45.0	

[1] Relatively free from dirt and with no visible scab spots.

The results show that there is an increase in the percentage of scab in the product of each successive unit of seed treated. It is reasonable to infer that the increase in scab is a result of decrease in the strength of the corrosive sublimate solution which, according to chemists, is due to a combination of a portion of the corrosive sublimate with the organic matter of the outer portion of the tuber. Table V indicates that a slightly greater loss occurs when scabbed tubers are treated than when clean seed is treated.

Another experiment was conducted to determine the loss of strength of the corrosive sublimate, by treating 12 consecutive lots of potatoes in the same solution. Analysis was made of the solution after each treatment. The results are given in Table VI.

Corrosive sublimate loses strength with each successive treatment. Unless the solution is strengthened each time by addition of more of the chemical but little germicidal action will result after the third or fourth treatment.

TABLE VI.—LOSS OF STRENGTH OF CORROSIVE SUBLIMATE WITH TREATMENT OF 12 CONSECUTIVE LOTS OF POTATOES

Treatment	Per cent of standard strength[1]
Original solution	91.0
After 1st treatment	75.0
" 2nd "	66.0
" 3rd "	57.0
" 4th "	46.0
" 5th "	35.0
" 7th "	26.0
" 9th "	16.0
" 12th "	6.5

[1] Standard strength solution of corrosive sublimate is 4 ounces to 30 gallons of water, or 1 part of the chemical to 1000 parts of water.

Where relatively small amounts of potatoes are to be treated, it has sometimes been found convenient to increase the time of treatment for the second lot to 1¾ hours, for the third lot to 2 hours, and that for the fourth lot to 2¼ hours, where no chemical has been added. This practice, however, has not been established by definite experiments under Wisconsin conditions.

INFLUENCE OF SOIL TREATMENTS ON SCAB

Experiments were conducted at Madison in 1916 to determine the influence of manures, lime, wood ashes, and sulphur on the development of scab. The soil in the plots was a medium clay loam. The manures were applied to the surface in a relatively fresh condition and were carefully worked into the soil. The same practice was followed in applying the other materials. The rate of application, the number of units or individual experiments, and the percentage of scab are given in Table VII. Rural New Yorker and Green Mountain, the two leading late varieties of potatoes in Wisconsin, were used.

The potatoes grown in plots receiving applications of horse and cow manures had the highest percentage of scab, and this was a decided increase over that in the controls. Field observations during five seasons support these results. The reason for this increase is rather difficult to explain. The manures

may exert some physical influence on the soil which is favorable to the development of the scab organism. Moreover, it has been noted that manures, especially horse manure, favor the growth of organisms which belong to the same group as the scab organism.

FIG. 10.—ROUGHENED SURFACE

This checked condition may be caused by unfavorable soil conditions, especially in heavy soils. It is sometimes confused with scab and black scurf injury.

The amount of surface infection by scab on tubers from manured plots was much greater than in the controls. Therefore, the percentage given is not a true indication of the relative infection. A high percentage of tubers in the fertilized plots would grade second quality because of their unsightly appearance.

Air slaked lime and unleached wood ashes added to the soil increased scab. These materials reduce the acidity of the soil and no doubt produce a condition favorable to the development of scab. It is generally supposed that the scab organism

is favored in its growth by a soil which does not give an acid reaction.

In general, results show that the most scab occurred in the units receiving the heaviest applications. A gradual reduction occurred as the amount of manure, lime, or wood ashes was reduced.

TABLE VII.—RESULTS OF EXPERIMENTS ON THE INFLUENCE OF CERTAIN SOIL TREATMENTS ON SCAB

Average of Rural New Yorker and Green Mountain varieties

Treatment	Amount per acre	No. of units	Average per cent scab
Horse manure (fresh)	25.0 T	2	75
	12.5 T	2	69
	7.0 T	2	56
Cow manure (fresh)	25.0 T	2	79
	12.5 T	2	71
	7.0 T	2	75
Lime (air slaked)	220 bu.	2	69
	110 bu.	2	62
	55 bu.	2	48
Ashes (wood)	200 bu.	2	62
	100 bu.	2	52
	50 bu.	2	39
Sulphur	900 lbs.	2	27
	450 lbs.	2	36
Tubers treated with corrosive sublimate:		4	3
Formaldehyde		3	7
Untreated potatoes or controls		10	39

In one plot, less scab occurred on the units treated with sulphur than on the controls. The percentage of scab increased with the decrease in the amount of sulphur applied. Results in another plot, however, showed no beneficial influence from sulphur. In view of these results and because of the high cost

of this treatment, sulphur cannot be recommended at this time. Inoculated sulphur may find a place for itself in the future, as experiments reported from New York and New Jersey show that it has some value in the control of scab when harrowed into the soil just before planting.

Both corrosive sublimate and formaldehyde reduced scab decidedly. Corrosive sublimate, however, proved the more effective.

FIG. 11.—SEED TREATMENT IS WORTH WHILE

Treatment reduces the danger of introducing disease germs into the soil with the seed. Potatoes should be laid out in half light on floor or canvas, either loose or in crates, to allow strong sprouts to form after treatment.

OCCURRENCE OF SCAB ON SIX STANDARD WISCONSIN VARIETIES

Along with the study of seed disinfection, there was opportunity to determine the occurrence of scab on six standard varieties of potatoes. Results were obtained by determining the average of scab in the product of control (untreated) units planted to clean or relatively clean seed. All varieties were planted at approximately the same date.

The lowest percentage of scab occurred on the Rural New

Yorker, one of the leading late varieties, and the highest percentage on the Irish Cobbler, a leading early variety. Field observations throughout leading potato sections, in connection with seed potato inspection covering six years, substantiate these results. They show that the late varieties have a lower percentage of scab than early varieties. Whether this is due to varietal susceptibility or whether some other factor or combination of factors is the determining agent remains to be decided through investigations now in progress at the Agricultural Experiment Station.

TABLE VIII.—OCCURRENCE OF SCAB ON SIX LEADING WISCONSIN VARIETIES

Varieties	No. of units	Average per cent scab
Late varieties		
Rural New Yorker	17	24
Burbank	10	32
Green Mountain	9	40
Early varieties		
Early Ohio	11	44
Triumph	5	51
Irish Cobbler	7	62

During the hot summer of 1916, scab was especially severe. That temperature may be an important factor seems plausible as a result of the investigations of the past year. Greenhouse experiments show that a moderately high temperature favors the development of the disease. Since the early varieties usually develop tubers during the hotter portion of the season, it is reasonable to suppose that if relatively high temperature favors the disease these varieties will have more scab than the later varieties, which usually develop when the temperature is much lower.

A tendency was noted also toward heaviest scab infection on the stem end of tubers. This was especially true of the Burbank variety. This would indicate that infection took place in the early development of the tuber during the hotter portion of the season. It appears that the enlargement of the scab areas is associated with the growth of tubers.

Another indication that scab develops early in the season is that the scabbed potatoes average considerably higher in weight than the clean stock. Their increase in size is, of course, due to a longer period of growth.

Field observations and reports by growers indicate that when the early maturing varieties are planted late they do not have as high a percentage of scab as those planted earlier. This is particularly true of Triumph. This merits consideration since other diseases, as tip burn and various leaf troubles, also occur less severely in late-planted early varieties.

TREAT SEED POTATOES

Control scab, black scurf, and black leg.

Corrosive sublimate is the best disinfectant to use.

Treat uncut seed; if possible treat it ten days or two weeks before planting.

The proper strength is 1:1000, or 4 ounces to 30 gallons of water.

The time of treatment recommended is 1½ hours for dormant seed; if seed has commenced to sprout, reduce the time but soak at least ½ hour.

Keep up strength of solution by adding ⅜ ounces of chemical after treating each 4 bushels of potatoes 1½ hours and restoring the volume of water to the original 30 gallons.

Throw away the treating solution after the third or fourth treatment, when no chemical has been added. In this case, increase the time of treatment 15 minutes for each consecutive lot treated.

Use wood or cement containers, such as barrels or tanks. Galvanized iron tanks may be used if protected by asphaltum paint. Corrosive sublimate eats holes in unprotected metal.

Corrosive sublimate is a deadly poison if taken internally. Therefore, be very careful to keep it away from children and all farm stock. The solution is colorless, tasteless, and odorless, and likely to be mistaken for water if left exposed. **Do not use** treated potatoes for food.

Formaldehyde is sometimes used at the rate of 1 pound to 30 gallons. Soak the uncut seed 2 hours. In case sprouts have started, there is less injury than where corrosive sublimate is used. It is not as efficient as corrosive sublimate in controlling scab and black scurf.

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Bulletin 332 April, 1921

Farms follow Stumps

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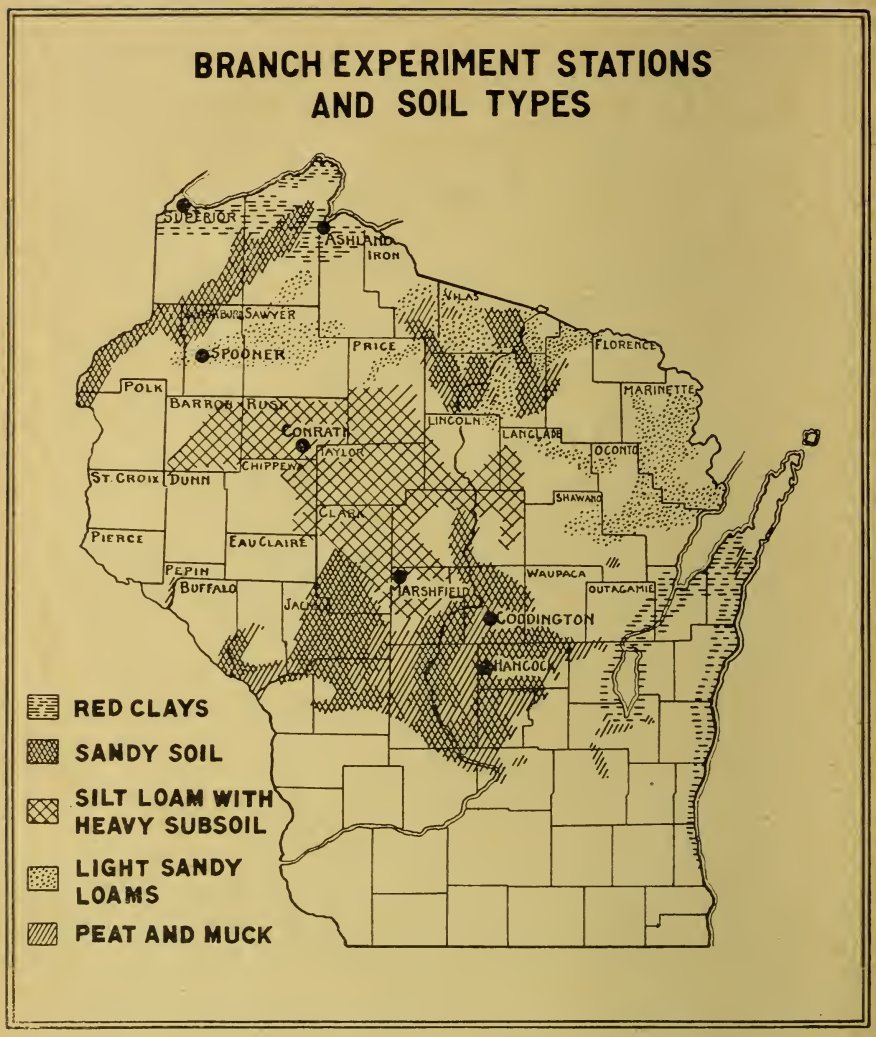

E. J. Delwiche of the Agronomy Department (R. A. Moore, Chairman) has had immediate charge of the field crops work for Upper Wisconsin and has also served as Superintendent in charge of the Ashland Junction and Spooner Stations since their foundation.

F. L. Musbach of the Soils Department (A. R. Whitson, Chairman) has had supervision of soils work at the three stations and has also acted as Superintendent of the Marshfield Station.

Horticultural work (orchards) under direction of J. G. Moore, Chairman, Horticultural Department, is in progress at Ashland Junction; potato investigations under J. G. Milward at Spooner. Dairy herds (Guernsey at Spooner; Holsteins at Marshfield and Ashland) have been under supervision of G. C. Humphrey, Chairman, Animal Husbandry Department.

Farms Follow Stumps

H. L. Russell

OVER 80,000 years ago ice more than one-quarter mile deep covered all but southwestern Wisconsin. Great continental glaciers swept down from the Canadian Highlands during the Ice Age to plough and scour the underlying rocks that make up the core of the continent. These glaciers scraped out lake beds, changed the courses of rivers and leveled hills, while the grinding of the ice against the rock beds and the wearing down of the boulders by the water produced the rock flour now found in silt loams, clays, and sands.

The retreat and advance of several such ice invasions made Wisconsin soils much more complex and varied than those farther south. Most of these soils are productive if properly managed, yet the crops grown on sandy loam may not be adapted to red clay or clay loam. While a large area of the state is being successfully farmed, over 100,000 farms of 80 acres each are still waiting for the settler in upper Wisconsin; and if the settler is to succeed he must know what crops grow best on his particular soil. The farmer from the prairies cannot grow the same crops in upper Wisconsin that he raised on his old farm.

Years ago the central farm of the Agricultural Experiment Station was begun at Madison on a highly fertile soil known as the Miami silt loam. This is the most common soil type of eight counties in the southwestern part of the state, but represents only a small part of Wisconsin's soil and climate. Since the soils could not be moved to Madison for study except in the laboratory or green houses, it was necessary to go where the dominant types exist. Accordingly the legislature of 1909 authorized the establishment of branch experiment stations. These stations perform work for hundreds of farmers in the state at low cost, and the results help the settler build both his home and his farm.

Diverse conditions of soil and climate, the heritage of the Ice Age, are thus being turned to the advantage of the commonwealth and the promotion of better agriculture.

MILESTONES PASSED

In ten years 12,000 new farms have been made for upper Wisconsin and the branch stations have worked not only to take care of these new farmers but also of those who lived in the country before extensive immigration began. Land clearing work has resulted in the clearing of more than 50,000 acres a year for ten years (80,000 in 1920). More and more land is yearly being brought under the plow through the efforts of the land clearing division of the College of Agriculture, cooperating with the State Department of Agriculture, bankers, railroads, powder companies, and farm organizations.

The corn of upper Wisconsin was once a mixture of red, white, yellow, and black, so that it was well called "calico corn". These scrub varieties were low yielders, often failing to mature and gave generally unsatisfactory results. Now the introduction of the standard corns that have been bred primarily to meet the climatic conditions of the new north, such as Wisconsin No. 25, Chippewa Flint, and Wisconsin No. 8 and 12 have substantially replaced the old types. Every county in upper Wisconsin is today represented in the membership of the Wisconsin Experiment Association and these men make their farms the centers for the dissemination of pure-bred seeds throughout their section.

Livestock farming has been found profitable and the interest of some counties has been so stimulated that they are boasting of having every sire purebred. Several counties have campaigns under way for the elimination of every tuberculosis-infected animal in the county and their reputations are already becoming established among breeders outside of the state.

Land clearing, livestock, and legumes, are the three L's which have changed the timber and the "cutover" country into developed farms and homes. Wisconsin is only beginning to develop her untamed empire, but in it she has rich resources whose value as yet can only be estimated.

For the new settler who comes from the prairie states or has been accustomed to land altogether different in quality, the

Stations Spread Farm News

work at the branch stations has been a boon and has saved many a farmer from making what would have been costly errors.

Each of these soil types needs special study. The problem is to develop sand crops for the sand farmer, clay crops for the clay farmer and marsh crops for the marsh farmer. Each experiment station is the center for the distribution of agricultural information and knowledge which has been collected, and proved in actual farm practice. Demonstrations are held annually at the respective branch stations during the growing season. Last fall at Spooner (August 4, 1920) over 1,500 persons attended a demonstration where the speakers used as their texts the results of various experiments conducted on the farm. A three-day school at Marshfield was visited by over 3,000 persons from the surrounding counties, some coming in groups encouraged by their county agents, others singly with their families, and all anxious and ready to learn new things in farming. In 1920 over 400 samples of small grains, corn, peas and beans were shown at the Ashland mid-winter grain shows. Over $300 was contributed by private individuals and firms for

premiums. Visits from individual farmers occur almost daily at each of the stations. Some of these men are prospective settlers, others are seeking information on various matters which have arisen in their own farming practice. More and more the farmers in the vicinity of the branch stations are relying upon the work of the scientist in verifying results and recommending cultural and cropping practices.

FIG. 1.—MORE CLEARED ACRES MEAN SUCCESS
Rail fences and makeshift shelters are only stepping-stones to prosperity

The following stations have been located since 1909: (See map inside first page).

At **Ashland Junction,** four miles west of Ashland in 1911 on the heavy red clay (Superior type). This soil is characteristic of 3,000 square miles of good agricultural land tributary to the south shore of Lake Superior as well as that of the upper portion of the Lake Michigan shore and the Green Bay peninsula including the lower Fox River valley. One-hundred and sixty acres of wild land was purchased jointly by Bayfield and Ashland Counties and deeded to the University. To this an additional tract of 22 acres was added later by purchase.

At **Spooner** in Washburn County was located the station for the light sandy loam types that are so largely covered with jack pine growth. Over 5,000 square miles of this soil type exists in the northwest and northeast sections of the state. The city of Spooner donated 80 acres of such soil immediately adjacent to the city boundary in 1909; an additional 80 acres were added by purchase for $1,200 in 1910.

In clearing this land, shelter belts were left on three sides of the field to lessen wind injury. The soil is quick acting, subject to drought, naturally deficient in organic matter and phosphorous and more or less acid. Under the old methods of cultivation such soils rapidly deteriorate and the initial organic matter is burned out so that wind injury is increased. The station is now raising legumes as a forage crop and plowing under the stubble as one means of building up the nitrogen and humus content of these soils and of producing excellent crops of corn and potatoes.

The **Marshfield** Branch Station represents the large area of 5,500 square miles of silt loams (Colby and Kennan) found in central north Wisconsin. On this heavy and fine grained soil, cultivated crops suffer from excess of moisture unless provision is made for surface drainge. The country is gently rolling and sweeps along in a series of lowlying hills and valleys. In 1912 Marshfield and Wood County realized the good which would come from an investment in a branch station and purchased 80 acres of land which was given to the state. By an act of the Legislature in 1919 a supplementary farm of 100 acres was purchased for $15,000. This station lies at the southern edge of the Colby silt loam and because of the fine grained texture of the soil and the retentive subsoil offers its major problems in soil and fertilizer treatments.

Two other stations have recently been established in the central part of the state. These, however, are supported from a separate fund and are on leased land. They have not been in operation long enough as yet to warrant presentation of experimental results.

At **Hancock** in Waushara county on the very light sand soils, a 76 acre farm that was badly depleted in fertility has been the basis of soil improvement work by the Soils department.

At **Coddington** in Portage county a 40 acre tract of acid peat is in use. These locations are typical of 5,000 square miles of sandy soils and 2,000 square miles of marsh lands in the central and upper portions of the state.

Two county demonstration stations are also maintained where the work is purely demonstrational. The work of the Marshfield Branch Station on the Colby silt loam is carried to the Rusk County Demonstration Station at Conrath on

a very similar soil type (Kennan silt loam). The station has been in operation seven years and has been used as a basis for developing seed types for its particular region. The work of the Ashland station on the red clay is carried to the Douglas County Demonstration Station within the limits of the city of Superior on a similar soil type which is as yet inadequately drained.

A STORY IN FACTS

Since 1910 an average of 50,000 acres have been cleared every year in upper Wisconsin. Over 80,000 acres were cleared in 1920.

More than 12,000 new farms have been settled in upper Wisconsin in the last decade. There is now a total of 65,000 farms, a more phenomenal growth than that in the prairie states during the land boom.

Upper Wisconsin in 1919 produced 37 per cent of the field peas, 34 per cent of the clover and timothy, and 47 per cent of the potatoes grown in the state.

With only 27 per cent of the tilled farm land, upper Wisconsin already has 29 per cent of the total dairy cows of the state.

Wisconsin's acreage in farm land has increased about 1,000,000 acres since 1910 but nearly 600,000 of that new acreage has been added in upper Wisconsin.

It would take 500 trainloads hauling 40 cars each to carry upper Wisconsin's annual potato crop to market.

Wisconsin produces over 60 per cent of the nation's cheese, while the upper 29 counties alone produce 22 per cent of the nation's total.

The first land clearing train in America was run by the College of Agriculture in 1916.

Upper Wisconsin already has as many dairy cattle for an acre of improved land as the state average and is growing rapidly.

LIVESTOCK FOR THE SETTLER

IN ten years upper Wisconsin counties have increased the number of milk cows over 200,000. While 1910 counted a few more than 300,000 animals, 1920 records show more than a half-million milk cows in the upper 29 counties of the state. Ten years ago the silos were not figured in the statistics; today there are nearly 20,000 in upper Wisconsin. Once the settler is established on his farm and sure of his prospects, he builds up his dairy as he drives back the brush line.

Just as the settler is compelled to start with grade or even scrub cattle, so the three branch experiment stations began. At Spooner in 1912 nine cows were purchased—the price ranging from $25 to $75. Work was begun upon this rough, native material to teach upper Wisconsin settlers the value of pure-bred sires.

At Spooner no particular effort was made to buy exceptional cows; they were black, red and even blue-roan and were purchased directly from settlers or from men in the county at the time. Later a Guernsey sire was purchased for $150. This sire was used by both Conrath and Spooner stations, thereby saving additional costs, and also showing the settlers that neighborhood sires were not only possible, but advantageous.

Sixteen grade Holsteins were purchased for Ashland in 1915, and from this foundation a demand has sprung which has

utilized all the available breeding stock that could be spared from the station. In June 1920 the mature Holstein bull, Crescent De Kol Hengerveld Prince #187924, which had been in the Ashland herd for two years, was sold to the Chequamegon Holstein Association of Ashland to become a community herd sire, and to use with 41 mature purebred Holstein cows imported by that Association from Dodge, Washington and Jefferson counties. The branch station herd has been an actual demonstration to the upper Wisconsin settlers, proving to them not only the value of livestock, but the possibilities in management. The herds are managed according to dairy practices recommended for upper Wisconsin farmers. They serve primarily to teach the use of feed grown on the farm including roughage and grains not suitable for seed purposes. To the visitors and delegations of farmers at the Station Day meetings, demonstrations show the types of cows and the methods of breeding and feeding which make dairying more profitable.

While progress on the branch station farms is being made in establishing purebred families of cows related to those at the Madison station, the process has been gradual. Visiting farmers were given feed rations for cows and calves; they were given access to the record of production and learn by seeing the value of purebred sires. A record of the purebred sire campaign in nine counties shows increases of from 3 to 23 per cent and a total of 965 bred-for-production sires.

The herds at the stations have always been tuberculin-tested regularly, and this practice in turn has been reflected upon the countryside. Barron is the first county in the United States to be completely free of tuberculosis infection in its dairy cows. Already out-of-state buyers are watching this pioneer attempt with interest, and undoubtedly counties desiring to keep their reputation will also be compelled to test their herds.

With 37 cow-testing associations, 34 breeders' organizations and 940 butter and cheese factories, upper Wisconsin shows that it has "arrived" as an important dairy region. Farmers often find it easy and profitable to pasture their cows in cut-over lands of the farm during the summer and feed through the winter with either silage or some root crop. Following the p licy of the Branch Station, many farmers are now making their small herds the foundation for purebred families of cattle.

BETTER SEEDS GOSPEL

SOYBEANS have been grown in southeastern Asia, China, and Japan for hundreds of years and in those regions are used as human food. Vegetable milks and flours are common and in some districts of China and Japan a special sort of cheese and a kind of bread are made from these beans.

Here in this country soybeans have not been used for human food (except as a war measure), but the bean has proved of much value as a feed and forage for animals. When first introduced into the United States it was thought that the soybean could be grown only in the warmer central regions, but plant breeding has again come to the aid of the farmer and in upper Wisconsin acclimated strains have now been developed that can be cultivated with complete success.

Early Black No. 1, a pedigree strain of soybeans developed

FIG. 2.—SOYBEANS—A CHINESE FORAGE PLANT
Adapted to Wisconsin soils.

at Spooner, has yielded 22.6 bushels an acre for a five-year average. The value of this crop may be appreciated when it is known that the seed sells readily for $5 a bushel, and that in addition soybeans are legumes which add materially to the nitrogen supply in the soil. While over 50 varieties have been on test, Early Black still is in the lead. It grows to a very good height, yields abundantly and retains its leaves until it is fully mature. The crop is especially adapted to the lighter soils but it also grows well on the silt loams.

SOYBEANS BUILD UP SANDY LANDS

Green-manuring trials, using either soybeans or serradella for growth of green material, have proved very successful under the supervision and care of F. L. Musbach. Plots at Spooner cover a four-acre field of sandy loam which was subdued in 1914; and the rotation consists of two cultivated crops, one hay and one grain crop. No stable manure or fertilizers of any kind were used, and the fields are laid out in a four-year rotation of corn, potatoes, oats and clover—a field of each yearly.

In this method no crop is grown for the simple purpose of plowing under, but the green manuring crop is planted with the corn; the corn is harvested for the silo and the green material is then plowed under. Corn is planted in rows 4 feet apart and the soybeans or serradella planted between the corn rows. Plow lands are laid out across the rows and a chain is used on the plow in order to help distribute the green vines in the soil. This cropping system has reduced the yield of corn only one-third, while it has increased the oat yield 18 bushels an acre following soybeans, and 15 bushels following serradella. Clover has averaged an increase of 15 per cent for four years, and potatoes have increased an average of 5¾ bushels an acre. In 1920, oats planted in this rotation yielded 63 bushels while in a rotation where no legume was used in the corn it yielded only 36 bushels an acre.

In such a rotation soybeans offer one of the ways by which the organic matter, and thus the water-holding capacity of the soil, can be increased. Soybeans aid the farmer who has only a limited amount of manure, who does not wish to lose the use of his and for a year and yet wants to build up the organic matter in his soil—thereby laying the basis for a permanent agriculture and better crops on his farm. Soybeans again show themselves the friend of the farmer of light soils.

GRAIN ON NEW SEEDING KILLS CLOVER CATCH

Poor catches of clover often result when an attempt is made to start new seeding by planting it with grain because of the low water-holding capacity of some of the sandy soils. The more rapid growth of the grain crop robs the young clover plants of their necessary moisture and they die from drouth starvation. The best remedy to overcome this defect is either to sow the clover alone without a grain crop or to cut the grain crop for hay when it is nearly all headed. If the rainfall is abundant the grain may be allowed to ripen, but more failures occur through the drying out of the young plants than from any other reason.

FIG. 3.—KNEE DEEP IN CLOVER AT THE SUPERIOR DEMONSTRATION STATION
No wonder this country is known as "Cloverland."

RYE ON UNPLOWED LAND

Rye is sometimes called the poor land crop because it is so dependable. This reputation has been admirably kept at both the Spooner and Ashland stations. The difficulty is encountered in an attempt to plow the land during the busy fall season of the corn and potato harvest so that it was necessary to work out a new method of procedure. One method is to sow the grain without plowing on the corn, potato, or soybean stubble. Another way is to broadcast the rye in soybeans just before the

last cultivation. Very little labor is required in this manner and yields of 30 to 40 bushels an acre have been obtained. Under general conditions of the lighter soils, land should never be plowed unless the ground is in grass.

WISCONSIN NEEDS HARDY ALFALFA SEED

Seed from alfalfa plants which have been growing on a sand hill at Ellis Junction for ten years produced plants which have not winterkilled in eight years. Freaks like this often occur in alfalfa, however, and fields exist in Wisconsin today which have been growing alfalfa for over 20 years. Over 100 selections have been made from the seed of the Ellis Junction plants and while seed from them will eventually be distributed

FIG. 4.—ALFALFA TALKS AT SPOONER
Legumes help light soil farmers build up the humus content.

throughout the state, the immediate problem is to obtain hardy seed for present use.

Seed has been produced successfully at Spooner; and Grimm alfalfa yielded 2 bushels of seed an acre. This permits a rea sonable return, although it does not compare with the yields obtained by western growers. Seed production depends upon the dryness of the air at blossoming time. The problem of working out a method which would enable us to produce our own seed and thus insure the planting of hardy acclimated varieties of alfalfa is of much importance to Wisconsin.

LAKE SUPERIOR WINTER WHEAT BELT

Winter wheat has generally given a larger yield than spring wheat and its growing has been encouraged. A ten-year average shows that winter wheat yielded 20.5 bushels while spring wheat averaged only 18.5 bushels an acre for the state at large. Whether in upper or lower Wisconsin the effect has been the same, and encouragement has continually been given toward using winter instead of spring wheat varieties.

The red clay of the Ashland region has offered a surprise. The work of the experiment station shows that *Bayfield, Ashland, Douglas and Iron Counties form a new winter wheat belt.* This belt has today excellent seed wheat of the pedigreed varieties. The pedigreed strains have proved far superior to the common strains year after year. Tests at the Ashland station show that Bacska No. 408 yielded 51.0 bushels an acre while the unimproved Kharkoff yielded only 34.1 bushels an acre. Bacska wheat has averaged 31 bushels an acre at Ashland for seven years, but two other pedigreed strains developed at Ashland surpass it—No. 11837 with 34.2 bushels and No. 11825 with 32.4 bushels average for seven years. These yields are nearly double that of the spring wheat for the same period.

FIG. 5.—WHEAT BRED TO RESIST WINTER KILLING

The variety in the center is severely winter killed; those on the outside resisted winter injury.

PEDIGREED EARLY JAVA HIGH YIELDING SPRING WHEAT

While the winter wheat varieties have been the highest yielders at Marshfield, and bear out results obtained at the other stations, a new variety of spring wheat has been bred. Planting winter wheat after corn is often impossible, and therefore in a rotation calling for wheat after corn, a spring variety is needed.

At Marshfield the new strain of Early Java, M 1611, yielded twice as much an acre as its parent and was very much superior in quality. The wheat proved much more resistant to rust and other diseases than the Marquis and Durum wheats. On a soil of medium fertility, a three acre plot yielded 19 bushels an acre. In 1921 it is proposed to grow Early Java Pedigree on more plots and thus prepare to disseminate the seed the following year.

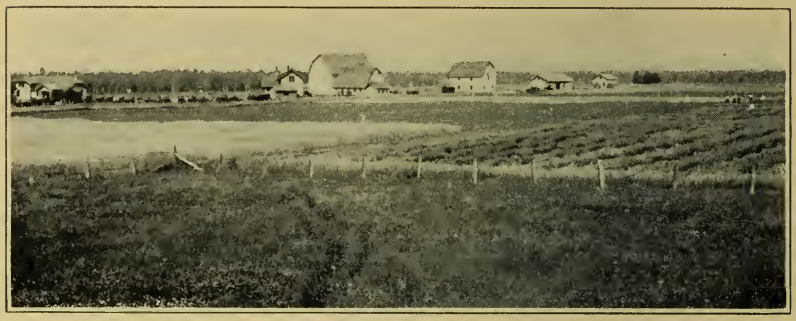

FIG. 6.—STATION DAY AT ASHLAND BRANCH STATION
Eight years ago this was a cut-over wilderness—now it is a fully developed farm.

PEAS PRODUCE AT ASHLAND

Twelve years ago the Experiment Station at Madison began work with peas under the direction of R. A. Moore. When the branch station was purchased at Ashland, however, all of the breeding work tending to improve the old varieties or to introduce new ones was transferred to that station under the direction of E. J. Delwiche. The cool climate in the northern section of the state makes this region especially adapted to peas. Over 250 varieties and strains are now on trial but only a very few will warrant selection and distribution to growers. Trials have been carried along with both soup peas and canning varieties, and several hundred acres of the new pedigree varieties are now being planted in upper Wisconsin. While only 30 per cent of Wisconsin's farms lie north of a line drawn west from the lower boundary of Door County to the southern boundary of Pierce, that area now produces 37 per cent of Wisconsin's dried peas.

Trials with field peas at Ashland, where the pedigreed peas were compared with the common, showed the advantages

of breeding work. The common stock produced 37.3 bushels of Green, 32.9 bushels of White Marrowfat, 33.6 bushels of Small Yellow and 31.4 bushels of Scotch, while the pure line varieties of the same produced 50.0 bushels, 36.5 bushels, 38.0 and 50.0 bushels an acre respectively for the same varieties in the season of 1920.

The increase ranged from 11 per cent for the White Marrowfat to 59 per cent for the Scotch, while the Green increased 34 per cent and the Small Yellow 14 per cent over the common strains. This shows the results which may be obtained from selection of seed and by the pedigreeing of those varieties which show promise. Not only has selection increased the value of the crop but better quality is obtained from pure line seed. The acre yields for Ashland on the two most prominent varieties have been 22.6 bushels for Green, and 22.9 bushels for Scotch during the ten years from 1908 to 1919. At Superior the average acre yield for eight years has been 21 bushels for soup varieties and 19 bushels for sweet wrinkled canners. At the Rusk County Demonstration Station the Green variety averaged 20½ bushels an acre for the last six years. A general average placed the *yield of the pedigree varieties five bushels more an acre than the yield of the state* for the same period. When they prove reliable, new strains will be sent out; Ashland and Superior stations now have 150 bushels of seed which will be distributed in 1921.

FIG. 7.—BETTER CANNING PEAS FOR WISCONSIN

Heavy yield, even maturity and disease resistance are the cardinal points for canners.

PEAS FOR CANNING INDUSTRY

The growing of seed peas for the southern canneries is a great opportunity for upper Wisconsin until the establish-

ment of canning factories. At present the greater part of the seed is shipped into the state yearly but the results of a test with a cross of the Horsford and the Alaska show good seed-producing possibilities and a resistance to root rot. This disease has caused much damage during the last few years. The new cross grew vines more than 2 feet high while the Horsford parent hardly reached the growth of 6 inches. The Badger and the Horal are two new sweet wrinkled canning peas which mature early, are prolific, and ripen more evenly than any other varieties so far tested.

Two canning factories have beeen established in upper Wisconsin, due to the stimulus given the pea industry by work at Ashland. The owners at Marengo and Merrill are enthusiastic; and the factories have been such a success that in the future more canning factories will, no doubt, be started on the virgin soils in the vicinity of Superior and Ashland. This new field for peas shows that while Wisconsin is already canning more than one-half the nation's peas, she has available an upper empire which can be cultivated to produce more than enough peas to fill the 7,000 miles of pea cans now packed every year in her factories.

SHELTER BELTS OF TREES PREV

WINDBREAKS FOR SPOONER STATION

Drifting sands are one of the drawbacks encountered in farming light soils. Drifting does not occur every year, but still is rather frequent. When it does occur, serious injury results to grains and especially to new stands of clover. The work carried on at Iron River in Bayfield County on Plainfield sand, as well as the experience of farmers in central Wisconsin, have clearly shown the necessity for protection from drifting.

When the Experiment Station at Spooner was established a plan was worked out to study the effect of windbreaks on the drifting of the soil. The land was originally timbered with a growth of jack pine and scrub oak but when it was cleared narrow strips of timber were left. These strips were 20 rods apart east and west and about the same distance north and south. The results have been very satisfactory. Strong winds which have caused considerable damage in unprotected localities have had practically no effect on clover—one of the essential crops on light solis. Checking with exposed locations showed clearly that the timber strips saved the clover by preventing sand blowing in summer and retaining snow in winter. Any winter killing that occurred was at the greatest distance east

WIND BLOWING OF LIGHT SOILS

of the protective strips of timber. Work with clover in check plots did not show any difference in yield of crops—the new strips as against those at a greater distance.

The beneficial results from protective timber strips show their importance in the management of light soils. Shelter

FIG. 8.—COMBINATION CRIB AND SILAGE
Wisconsin No. 25 leads the corn belt by 20 bushels an acre higher average yield.

belts may best be left when the farms are laid out but if the land has already been cleared, jack pine may be grown with ease and rapidity on these light soils.

NEW CORN FOR UPPER WISCONSIN

With the expansion of the dairy business in upper Wisconsin has come the need for a corn which will provide adequate forage for this region. For several years experiments aimed to improve the type of corn have been conducted at the branch stations. Efforts were made to secure early maturity of a type having a sufficiently large stalk to be suitable for silage, yet which would ripen with certainty each year so as to produce crib corn where the season was short or rather cold. While standard varieties of Wisconsin No. 7, No. 8, and No. 12 are of particular value for silage purposes and can be recommended highly for many localities, they do not mature early enough for widespread use in all upper counties. The new cold-re-

sistant corn has done much to carry the corn belt farther north, but it has remained for a new dent, Wisconsin No. 25, to combine the qualities of a crib and silage corn.

Wisconsin No. 25. This was produced from a cross between Wisconsin No. 8 and a small but very early maturing yellow dent which has been succesfully grown in the

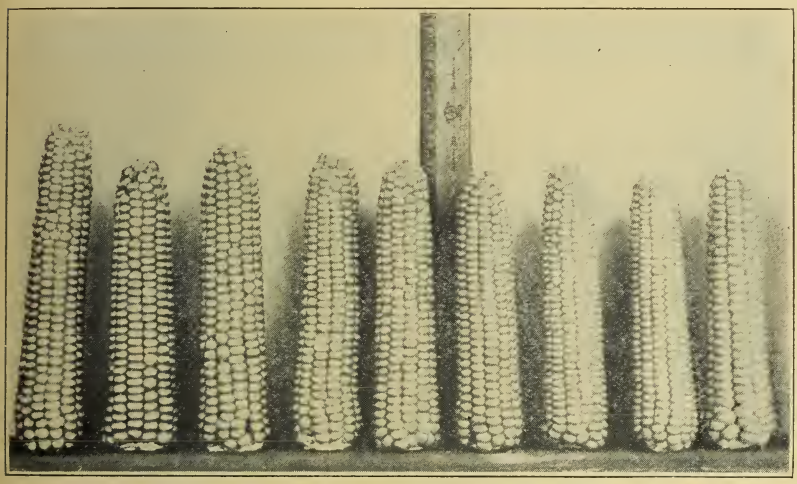

FIG. 9.—CHIPPEWA FLINT FROM THE INDIANS
A new flint corn which averaged 67 bushels an acre for three years at Ashland Branch Station.

cool summer climate on the Lake Michigan shore. After nine years of work a new strain has been developed, and at the Spooner station this variety has been found to ripen within 100 days. A good stand produces 60 to 90 bushels of shelled corn to the acre, or 20 bushels more than the average corn belt production in the central states. This variety is often ripe enough to permit seed selection on August 23, may be fully ripe August 30, and yet produces 8 to 15 tons of silage an acre. For seven years No. 25 averaged 57.4 bushels an acre, a yield of 22 bushels more an acre than the state ten-year average of 35.4 bushels. So extensive has been the seed dissemination that it is estimated over 4,000 acres of Wisconsin No. 25 are now raising the crop yields of the Spooner area in upper Wisconsin.

Chippewa Flint. A still earlier maturing variety of corn suitable to all conditions of soil and climate found in the northern portion of the state, is the small but well-eared variety of flint corn developed through hybridizing and subsquent selec-

tion. The parent stocks used in this breeding work were two strains of pure white flint corn secured from the Bad River Indian Reservation (Ashland County) in northern Wisconsin and the White Earth Reservation in northern Minnesota, where they had each been grown for many years by the Indians on these reservations. This corn is somewhat low in height, ranging from 5 to 6½ feet, grows generally two ears to the stalk, the average weight of ears being about two-thirds of that of Wisconsin No. 25. Under good soil conditions the yield of this corn on the Ashland Station (heavy red clay) was about 80 bushels an acre. Over a period of three years the new corn gave an average yield of 67.1 bushels of shelled corn an acre while the average yield in the state at large during the same period was only 42.0 bushels an acre. While this variety is small for silage purposes, it is suitable for crib corn and is well adapted to be hogged off because of the low height of the ears. Chippewa Flint is the name given to this newly domesticated and pedigreed Indian corn and with its distribution in 1921 will be completed the list of corn varieties for the entire state of Wisconsin.

SPREADING THE USE OF PUREBRED SEEDS

The Spooner station has been the distribution center for purebred seeds. Seed from the strain of Triumph potatoes, grown originally by J. W. Smith of Kent, and other varieties also have been sent to all sections of the state. Soybeans bred at Spooner have been sent to growers throughout this and adjoining states. One of the largest producing soybean centers, Stevens Point district, got its start from Spooner. Out-of-state and in-state corn growers have purchased seed of Wisconsin No. 8 and Wisconsin No. 25 corn. Some of the No. 25 has been shipped to Washington and Idaho. Pedigree 1219 rye, one of the hardiest ryes grown, was largely disseminated through this branch station; and the best strains of Pedigree No. 5 and Pedigree No. 2 oats have been distributed among farmers and seedsmen. The only limitation which has confronted the station is the ability to produce more seed, but even at present about 800 acres of oats, soybeans, No. 25 corn, and potatoes, are planted each year from seed furnished by the Spooner station. From these acres other farmers procure seeds and thus the pedigreed varieties spread from community to community throughout upper Wisconsin.

BETTER OATS

While winter wheat and peas have given excellent results at Ashland other grains have not been neglected. A new strain of oats No. 1214 has outyielded Pedigree No. 4 (Early Gothland) by

FIG. 10.—A HEAVY YIELDER NOT SUBJECT TO LODGING
To mature well, wheat must develop straw stiff enough to prevent lodging.

8 bushels an acre for a six-year average. In 1920, however, Early Gothland outyielded all other varieties and in spite of a season favorable to rank growth showed very little lodging. So far, Early Gothland seems especially adapted to upper Wisconsin.

CLOVERLAND

Attempts have been made to grow alfalfa at Ashland. While it pays to sow the crop on well drained slopes where water will not stand during the winter months, and while it produces nearly a ton more an acre than does red clover, still clover is to be recommended. Alfalfa is sensitive to excessive moisture, while clover grows like a weed in all parts of the country.

The clover seed industry of the Lake Superior region was started directly by the station. A clover huller was loaned to the farmers at the cost of labor. As a result, clover seed

growing is well established in the upper counties. Foxboro in Douglas County is the center of Alsike seed production while the territory near Ashland is noted for its medium red seed.

Peas, wheat, rye, and oat strains have been produced on the station and their seed disseminated to the farmers just as soon as enough is produced and the success of the crop is assured. Every season enough seed is sold to plant over 600 acres. Most of this goes to a new set of growers, thereby enlarging the pure-seed producing territory annually.

OVER 500 TRAIN LOADS OF POTATOES

If the potatoes raised in upper Wisconsin during the year 1920 were loaded on cars it would take 500 trains hauling 40 cars each to carry them to market. While the total potato acreage of Wisconsin in 1920 was 305,000 acres, probably 50,000 acres of this area had never before been planted with potatoes. Potatoes are a common crop yet it is estimated that from 3,000 to 5,000 men undertook to grow them in Wisconsin during 1920 without previous experience in growing and handling the crop under Wisconsin conditions.

Inexperienced men need help if they are to be successful in growing potatoes on new acres. Of the three branch experiment stations in upper Wisconsin no one is better suited to study potato raising than the one at Spooner. It has been organized to furnish practical information for those who are developing this industry in upper Wisconsin counties. The study of the potato problem and actual experience in field extension work shows that information is needed:

FIG. 11.—SPUDS MEAN MILLIONS
Potatoes are one of the cash crop friends of the new settler.

1. In the selection of varieties for special soil and cultural conditions;
2. In storing, handling and treating seed potatoes prior to the planting date;
3. In the choice of equipment, including machinery, sprayers for vine poison and spray mixture;
4. In fertilizing and handling northern soils consistent with rotation and maintenance of fertility.

FIG. 12.—BETTER POTATOES FROM CERTIFIED SEED
A field of Burbank Certified Seed on trial at the Spooner Branch Station.

THE RIGHT POTATO FOR THE RIGHT SOIL

For ten years the Spooner station has grown seven varieties under prevailing field conditions: Rural New Yorker, Burbank, Green Mountain, Early Ohio, Triumph, Irish Cobbler and Early Rose. All are standard varieties of recognized merit and available to the grower.

Not only yield, type, and quality have entered into the study of potato growing, but disease resistance has also been important. Trials over a period of five years show that the Rural New Yorker will outyield the Green Mountain on the Spooner branch station about 30 bushels an acre. The records further illustrate that in size of tuber, freedom from scab and disease resistant quality, the Rural New Yorker will average better over the same period. These variations show that

hardiness and vigor of the Rural New Yorker and its resistance against drought make it particularly adapted to the light sandy loam characteristic of the Spooner station and of thousands of similar acres in upper Wisconsin.

However, on the cool, deep, fertile sandy loam soils of upper Wisconsin that have depth and body and are retentive of moisture, the Green Mountain grows to such a high degree of perfection that it is preferred to the Rural New Yorker. Due to the work at the Branch Station it has been possible to guide the grower in the choice of varieties and to successfully counsel him against any investment in the wrong kind of potatoes.

IRISH COBBLER VERSUS EARLY OHIO

One advantage of investigation is to avoid mistakes. In 1920 a potato grower in upper Wisconsin planted 300 acres—150 acres of Triumph and 150 acres of Irish Cobbler variety. The Irish Cobbler crop was very unsatisfactory, and after an effort of three years to grow and improve the variety the planter will have to abandon it.

His results are identical with those obtained at the Spooner Branch Station with Irish Cobbler and Early Ohio. Although the vine growth is satisfactory and the yield good, the stock runs coarse and inferior in both type and quality. The desired type of the Irish Cobbler is a round, somewhat flattened or blocky tuber. On the Spooner station a very large percentage of the tubers were elongated, pear-shaped and resemble what is known as "Lady Finger" specimens—types especially objectionable in the seed trade. Unsatisfactory as the Irish Cobbler is, the Early Ohio variety has shown similar extreme variations as well.

While field inspection records show good Irish Cobbler sections in Barron County, Langlade County and in other counties where heavier types of potato soil prevail, yet as a result of the work on the Spooner station it has been possible to advise against the planting of Irish Cobbler and Early Ohio varieties on certain light sandy soils resembling Spooner types.

BETTER HANDLING METHODS

Attention has been given to providing good storage for seed potatoes, to exhibiting desirable farm equipment for treating potatoes and handling seed stock prior to planting,

to demonstrating efficient methods of handling poisons and spray mixtures, and to spraying and controlling insects and diseases.

The potato storage cellar at Spooner has a capacity of 2,500 bushels of seed. It cost $1,500, but it is estimated that 150 growers will secure foundation seed stock from this cellar in 1921. Practically all of the pure Rural New Yorker fields in Taylor County last year were planted from seed originally secured from the Spooner station five years ago by the county agent. By securing desirable storage facilities it has been possible to disseminate from 500 to 1,000 bushels of seed a year, and in most cases to direct this seed into territory where it is adaptable to the soil and climate of the community.

In a region where it is desirable to have the land fitted and seed in the right condition to plant by May 25, desirable handling equipment is important. The storage cellars contain inexpensive equipment such as crates and concrete tanks while a sorting room has been provided to sort, handle, treat and cut seed in the proper manner prior to the planting date.

The station has demonstrated that either paris green, dry arsenate of lead, arsenate of zinc, or calcium arsenate will control the potato beetle if sprayed correctly; and that the most important point is not the kind of poison but the date of application. As a result of these demonstrations potato growers are buying better equipment and using better methods in handling poison. They have learned the importance of timely spraying, application of the maximum amount of poison per acre, use of the proper kind of sprayer and nozzles; and the necessity of safeguarding against foliage injury.

Automobile excursions have been arranged during August and September to the Spooner station because when a man drives out to visit his neighbors he learns of their crop conditions and goes back inspired to do better work or to maintain the position he already has. The Wisconsin Potato Growers' Association holds a summer meeting at Spooner where it may study all the important strains of seed potatoes grown under inspection in Wisconsin. Experiments followed by a demonstration have helped upper Wisconsin growers to learn the conditions required for good commercial potato production in the state. Experiments on the use of fertilizers, spray mixtures, cultural practices and the selection of varieties for spe-

cific conditions have been followed up by demonstrations proving the points considered.

A DISEASE-RESISTANT POTATO FOR SOUTHERN MARKETS

Every year 2,000,000 bushels of Triumph seed potatoes are shipped from Wisconsin to southern truck centers. Because northern seed is generally freer of disease, northern growers have been selling their crop to southern gardeners who cater to the early market.

The seed from Triumph potatoes, however, which had yielded 200 bushels an acre in upper Wisconsin, gave only mediocre yields when planted by the Gulf State growers. High yielding strains in Wisconsin grown under favorable conditions show from 50 to 100 per cent mild mosaic. The crop planted from this seed in the South may develop the extreme dwarf type mosaic and give very poor results.

Other potatoes than the Triumph have shown a weakness, but this particular early strain has shown a decided tendency to become diseased with potato mosaic. To meet the problem 20 strains of Triumph gathered from upper state growers were put on trial at Spooner by J. G. Milward, cooperating with the United States Department of Agriculture. A wide variation appeared both in yield and in amount of infection.

Among these strains was one obtained from J. W. Smith of Kent, Langlade County, which proved much superior to all other strains in both 1919 and 1920. This particular selection showed remarkable resistance to mosaic. Counts on mosaic with this strain ran as low as 2 per cent with a maximum of 10 per cent. This condition is exceptional because normally good grades of Triumph seed often show from 30 to 40 per cent infection and exceptionally good seed may contain as much as 15 per cent of infected tubers.

The resistant strain was distributed among twenty growers during 1920. The seed stock sold in the fall of 1920 at $4.50 a hundredweight, and about three carloads are available for 1921 planting.

It is possible that within three years all of Wisconsin's fields of Triumph potatoes will be planted from this single source of resistant seed stock; and continued popularity in the southern seed market will be insured.

RUTABAGAS AN ECONOMICAL CROP

Seven different tests with different types of roots show that rutabagas are by far the best yielder for upper Wisconsin conditions. The best yielding mangels averaged only 13.6 tons an acre while the rutabagas yielded 22 tons in trials carried on at Ashland, Marshfield, Superior, and Conrath.

The new settler can hardly afford a silo and he often asks whether he can not raise root crops which will take the place of

FIG. 13.—RUTABAGAS ARE SILAGE SUBSTITUTES
Fourteen tons of feed an acre of rutabagas as compared with 8.7 tons an acre of corn was the three-year comparison at Ashland.

silage. Results which have been accumulated for several seasons at Ashland and Conrath stations show that rutabagas are the best root to grow and can be grown at less cost per ton than corn. The trials at Ashland were on the red clay while those at Conrath were on the typical soil of central Wisconsin, the Kennan silt loam.

Labor costs were calculated and the cost of slicing the roots was considered as well as those of filling the silo. The result was that in a three-year average at Ashland, corn cost $5.35 a

ton and rutabagas $4.06 a ton to grow for feed. The rutabagas yielded 14 tons of feed while the corn yielded 8.7 tons an acre. Still more striking results were obtained at Conrath for there the corn cost $5.49 a ton and yielded 9 tons an acre on a three-year average while the roots cost $2.51 a ton and yielded 20 tons of roots an acre.

These results show that rutabagas are an economical feed for upper Wisconsin, especially in localities where corn will not mature sufficiently for silage. In sections where large yields of corn may be secured, silage usually furnishes succulent feed more economically than do roots, for silage from well-matured corn contains nearly twice as much dry matter per ton as rutabagas or mangels.

UPPER WISCONSIN IS GROWING

Over 92 per cent of upper Wisconsin farmers own their own farms and homes. It is a country of landowners and working men and women.

Cows in upper Wisconsin average a return of $133 a year. With 504,000 milk cows in this cut-over region, the dairy industry alone is worth $67,881,000 a year.

Although there are 17, 651,000 acres in upper Wisconsin only 3,000,000 acres are yet in cultivated crops and tame hays.

In four years county agents have been instrumental in disposing of 6,250,000 pounds of explosives for land clearing.

Of Wisconsin's root crops, 67 per cent grow in the upper 29 counties.

Wisconsin is larger than England but has only one-fourteenth as many people.

Only 3.4 per cent of the area of upper Wisconsin is more than 10 miles from a railroad.

MARSHFIELD BRANCH STATION

SOLVING SOIL PROBLEMS

TESTING fertilizer to find out if Colby soils need more than manure has occupied F. L. Musbach for several years. The fields upon which the trials were made at Marshfield had been cropped for a period of 16 years, and the original owner had manured certain parts of the field more heavily than others so that the results were not as consistent as later work.

The addition of phosphate to stable manure has shown especial advantages in spite of the fact that the manure was produced from cows fed much better rations than they get on the average farm. Not only have phosphates brought about higher yields, but acid phosphate, which has given perhaps the best results, hastens the ripening of corn. Corn growing on untreated plots was only 2½ feet high on July 20; corn on plots which had been treated with 10 tons of manure, 750 pounds of acid phosphate and lime was 5 feet high and beginning to tassel; while corn growing on soil treated with manure and limestone, and manure, rock phosphate and limestone was only 3½ feet tall at the same time. Rock phosphate showed an advantage over the untreated plots, but the acid phosphate was superior with its growth of 5 feet.

With 10 tons of stable manure, 750 pounds of acid phosphate, and lime, the yield of corn was increased 12.7 bushels an acre, wheat 5.3 bushels, and oats 5.3. The first and second

crops of clover together were increased 1,500 pounds of hay an acre. The same amount of manure and lime, with 1,500 pounds of rock phosphate, showed an increase in yield for the same

FIG. 14.—UNTREATED PLOTS FAIL TO THRIVE
Corn on Marshfield silt loam (July 20) failed to produce vigorous healthy plants without some fertilizer. Compare with figure 15.

length of time of 11.0 bushels an acre for corn, 4.0 bushels an acre for wheat, 5.3 bushels for oats and 1,300 pounds increase for clover.

Acid phosphate made a better showing than the rock phosphate during the long period of time the trials were conducted. The use of gypsum and potash did not pay, but lime increased the yields of every crop to which it was applied. As a result of the excellent showing of lime as a soil builder, farmers in the adjoining counties have been purchasing large amounts of lime. One particular county alone has applied over 50 carloads to its fields.

PHOSPHATES AND MANURE AT ASHLAND

The clay belt around Ashland is essentially a section in which livestock raising and dairying will be important. The growing of small grains, moreover, has been particularly profit-

able. The grain farmer wants to know how he can best use manure and fertilizer, and what fertilizer he can buy to give the best results at lowest cost. The dairy farmer desires to make

FIG. 15.—ACID PHOSPHATE HASTENS GROWTH
Ten tons manure, lime and 750 pounds acid phosphate gave twelve bushels higher average yield per acre than on the untreated soil.

the best application of his manure and at the same time to prevent loss.

Acid phosphates and manure used together have given very good results. Last year they showed their adaptation to oats on the clay soils of Superior. Manure with 375 pounds of acid phosphate increased the yields 17 bushels an acre at Ashland, while manure with 1000 pounds of rock phosphate increased the yield only 13.9 bushels an acre. Manure with 500 pounds of rock phosphate, or with 250 pounds of acid phosphate, increased the yields 10 bushels an acre. While the trials ran only a single season the results were similar to those obtained at Marshfield. Both show that profitable results follow when stable manure is reinforced with phosphates.

TRICKS WITH DRAIN TILE

The opinion that drain tile would not work in the soils of the Colby type prevailed for a time. In order to obtain full

information on the question a tract of land on the Marshfield Station was set aside for the study of tile drainage.

Surface drainage has proved very useful and plot lands have been so laid out that the possibility of the fields draining

FIG. 16.—BUILDING UP POOR SOILS

A coarse sandy soil exhausted by 30 years' continuous cropping. Shock of corn on right grown on untreated soil. By plowing under green plant residues and the use of manure even these worn-out sands have been brought to grow a 67 bushel crop of corn.

off was very good. Unless some form of surface run-off is provided, heavy losses in the cultivated crops are frequently caused.

The experimental tiled plots were so laid out that yields could be obtained from strips of land at various distances from the tile. The general results show that due to the heavy soil, drainage is best when the tile is not over 3 rods apart. Under ordinary conditions tile has been laid 4 rods but the tests show that at 3 rods, corn was increased in yield 12 per cent with slight increases continuing as the distance from the tile decreased. Corn stover was similar to the corn grain with an increase of 10 per cent at 3 rods from the tile as compared to the yield 4 rods from the tile. Barley seemed to be little affected until it reached a distance of 2 rods from the tile. Then it showed a 6 per cent increase yield over the farther distance of 4 rods. Potatoes showed most marked results in yield, 5 per cent at 3 rods, 10 per cent at 2 rods and 20 per cent at 1 rod. Alfalfa showed little preference for the soil at 3 rods over that at 4 rods, but at 2 rods the increase was 6 per cent.

The increase in the yield of potatoes has been the most striking of any crop, although corn also showed good returns. Alfalfa indicated no decided results but preferred well drained subsoils. Four rods between the tile is certainly too far according to these results. Three rods gives much better crops.

Shall We Plow Deep or Shallow?

Owing to the peculiar hardpan soil in much of the Colby area, it was a general opinion that deep pulverization would permit deeper root growth and thereby increase the yields. Eight years ago experiments were begun at Marshfield. A series of plots were set aside for test with deep tilling, subsoiling, deep fall plowing, shallow fall plowing, and spring plowing.

Deep tilling and subsoiling have given negative results so far as a general rule. Deep fall plowing has been the same except with corn and the first crop of clover. Spring plowing has increased the yields of corn and oats only very slightly.

Light Sands And Marsh Soils

Work on the light sandy soils at Hancock, Waushara county, was established on rented land in 1916. When taken over, the land had been farmed for many years by renters and was about as low in fertility as possible, yielding in 1915 only five bushels of rye per acre, 20 to 25 bushels of corn, and about 75 bushels of potatoes. These very light sandy soils, representing large areas in the central portion of the state, are also represented in the distinctively jack pine plains of a number of the northern counties.

Through the use of various legume crops at Hancock the Soils department has already been able to build up the soils materially so that fair crops are now being secured.

Near Coddington on the Buena Vista drainage project located in Portage county south of Stevens Point, a small experimental area of 40 acres was started in 1919 on the acid peat soils that characterize much of the marsh areas in the central section of the state.

These soils often lack thorough drainage, are low in mineral plant food, and not infrequently are injured from summer frosts. As central and upper Wisconsin have fully a million acres of acid peat soils, it is of much importance that methods be worked out to ascertain their relative values.

Work at these two stations, Hancock and Coddington, is fairly under way, but sufficient experimental results have not yet been secured to warrant presentation.

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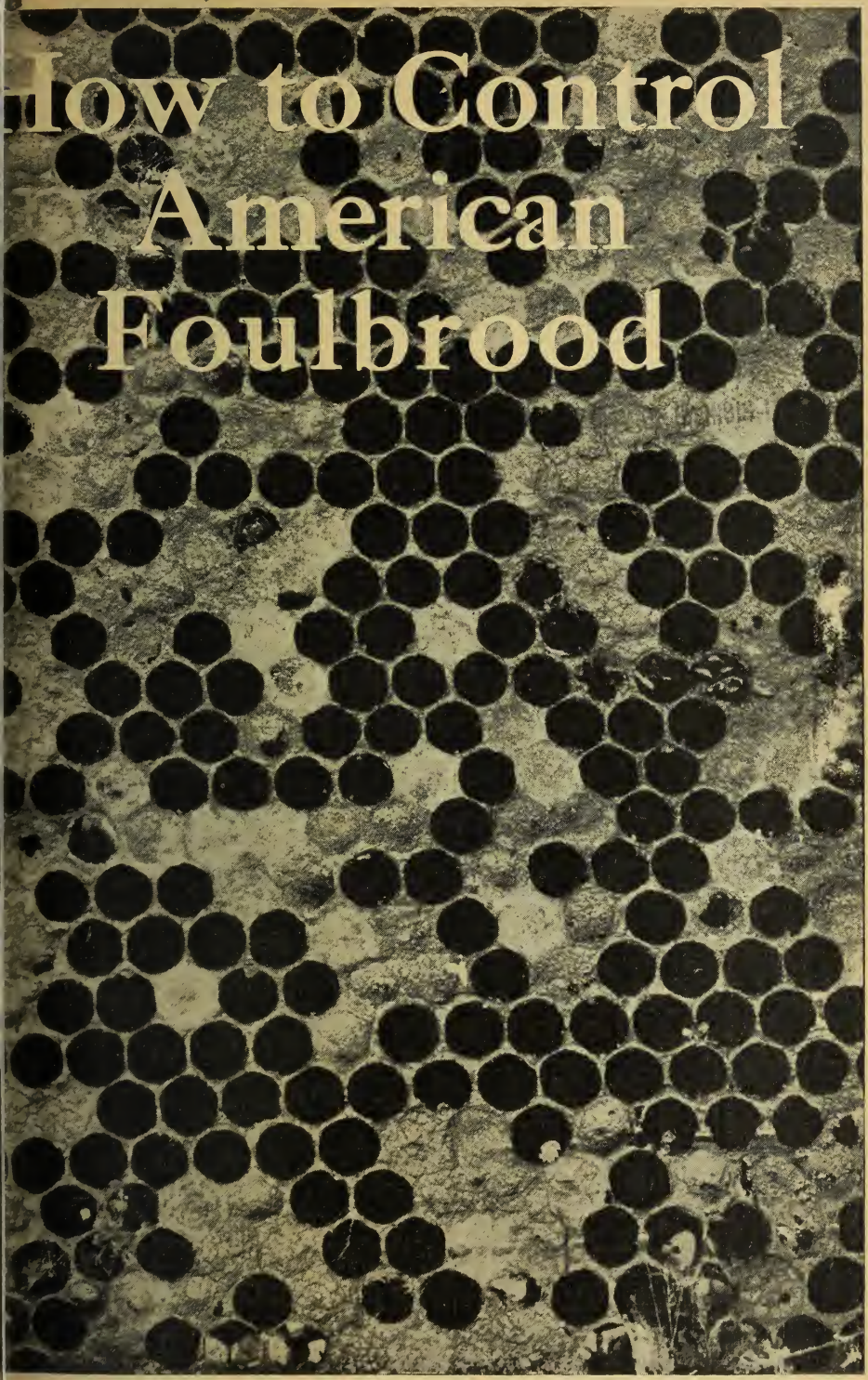
How to Control American Foulbrood



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DIGEST

American Foulbrood is the most serious disease of bees in Wisconsin. It is a bacterial disease carried in the honey and in old combs. Getting rid of infected honey and combs means the eradication of the disease. Pages 3-10

Extracting frames should not be saved. Although they may appear to be free of honey, there is always a possibility of a few drops of infected honey being carried over. Page 11

Scorching hive parts does not insure complete disinfection. Drops of honey may be left behind the rabbets or smeared on the outside of the hive although the hive may be carefully scorched on the inside. Page 12

Treating for Foulbrood must be carefully done to insure success. Careless handling of diseased colonies is sure to spread infection. Pages 14-20

How to Control American Foulbrood

H. F. Wilson.

Ridding Wisconsin apiaries of foulbrood is almost entirely in the hands of beekeepers themselves. Through co-operative effort only can the amount of disease be reduced to a minimum. In counties where local beekeepers' associations exist they are organizing clean-up campaigns and with the help of the state apiary inspector are getting the better of the disease.

Wisconsin is a beekeepers' paradise, for failures are few and almost the entire state is covered with flowering plants that secrete nectar readily. But for 20 years beekeeping has suffered from a slowly-eating cancer that at one time threatened to wipe out the industry. Between 1900 and 1918, bee diseases and winter losses caused a decrease of from 30 per cent to 50 per cent of all colonies. Shortly before 1918 the interest among beekeepers had fallen to its lowest ebb and it was a common sight to see hundreds of empty hives instead of prosperous and productive apiaries. Fortunately the disease situation is improving and American foulbrood, the chief offender, is slowly being eradicated through better inspection laws and more educational work.

The three brood diseases of bees more or less common in Wisconsin are American foulbrood, European foulbrood, and sacbrood.

American foulbrood occurs wherever it has been carried either by human agencies or by the bees themselves. European foulbrood and sacbrood do not occur in a virulent form over all regions of the state; and there is a direct influence of climate and nectar secretions on both of these diseases. Sacbrood is more widespread and has caused more trouble this past season than in any of the four years previously observed. Its range does not appear to be entirely affected by the same

factors that influence European foulbrood. The latter disease is found more or less in all sections of the state, but occurs in a highly virulent form only in certain areas in the northwest, west, and northeast parts of the state. Sacbrood is more or less sporadic in all parts of the state.

BACTERIA CAUSE AMERICAN AND EUROPEAN FOULBROOD

White[1] has clearly demonstrated that the three brood diseases of bees known as American and European foulbrood and sacbrood are caused by bacteria. The bacteria may be isolated and the disease transmitted in the laboratory as well as in the field. Sacbrood, according to his investigation, is caused by a filterable virus.

Each disease develops symptoms peculiar to itself; and when these symptoms alone are present, it is not difficult to determine the specific disease. Unfortunately, however, there are several other bacteria which live on the decaying larvae and sometimes cause symptoms similar to those of American foulbrood to occur with European foulbrood and sacbrood. This often leads to confusion not only in the minds of inexperienced beekeepers but to experienced men as well.

Persons of the widest experience are often misled by some unusual symptoms. The only sure way of determining the kind of disease is through a microscopical examination. If a beekeeper finds diseased brood in a colony and does not know the cause, he should immediately cut out a sample and send it in to the state apiary inspector or to the apiarist at the state experiment station.

GENERAL SYMPTOMS OF AMERICAN FOULBROOD

Sunken cappings often punctured, together with dead larvae chocolate brown in color, are symptoms of the disease. The larvae cannot be removed from the cell but string out when the attempt is made. When the disease is first introduced into a colony (Fig. 1) the few cells which occur may be overlooked easily. Just after death the larvae are a light coffee color which gradually becomes darker. Finally, when decay is well advanced, the larva loses its shape and melts down. In this stage the mass is quite stringy or ropy. As it dries out a scale

[1]White, G. F.—Sacbrood: Bul. 431, U. S. Dept. of Agr., 1917.
American Foulbrood: Bul. 809, U. S. Dept. of Agr., 1920.
European Foulbrood: Bul. 810, U. S .Dept. of Agr., 1920.

is formed in the bottom of the cell which can hardly be removed without breaking the cell wall. In examining old combs for the presence of these scales, they should be tilted at an angle so that the bottom of the cell can be observed and the light reflected so that if any foreign substance is present it can be seen.

The disease gradually spreads through the brood nest and normally becomes widespread by fall (Fig. 2). A colony usually dies out completely by the end of the second season or is so weak in bees that it dies out in the winter or early spring. A very distinct and disagreeable odor accompanies severe cases.

General Symptoms of European Foulbrood

Larvae usually die in younger stages and before cells are capped over. It is not uncommon for some cells to be capped and punctured as in American foulbrood. This confuses the beekeeper; and samples should be referred to some authority for identification. The disease appears worse in late spring and early summer when hundreds and even thousands of larvae may die in a few weeks. The disease becomes less severe as the season advances and may be entirely eliminated by the end of the season if there is a good honey flow.

The dead larvae are a greyish yellow at first and later turn to a chocolate brown. They melt down or lose shape and are found mostly at the back of the cell. The scales formed by the dead larvae are mostly loose and can be removed by the bees. They can often be jarred out and can be picked out without breaking or rupturing the cell wall. Older larvae break down and cannot be removed entirely. The tissues do not string out like the larvae in American foulbrood, but are chunky and have the consistency of cornstarch pudding.

General Symptoms of Sacbrood

Sacbrood is not unlike American foulbrood in some of its stages and might easily be mistaken for it. The larvae die after the cells are capped and the bees may remove the entire capping or puncture the cells as in the case of American foulbrood. There is a decided difference with sacbrood, however, in that larger punctures are made and usually only one.

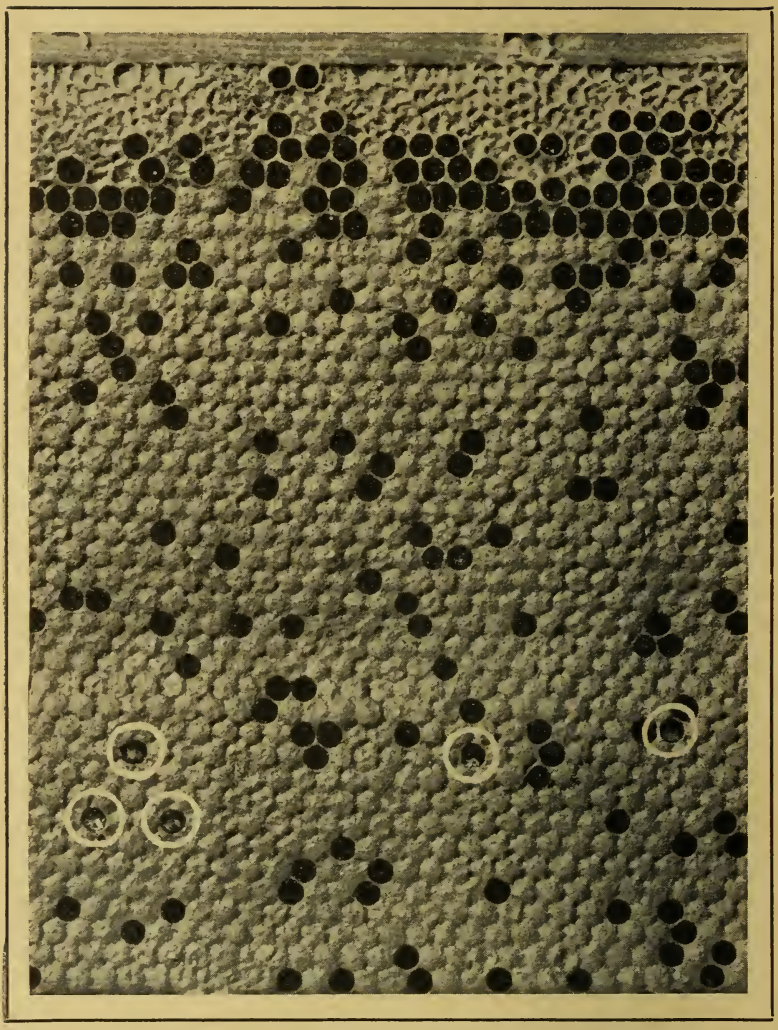

FIG. 1.—HOW AMERICAN FOULBROOD STARTS IN THE BEE COLONY

The white circles indicate five cells in which the larvae are diseased. No other cells could be found in this hive at that time, June 10, 1919.

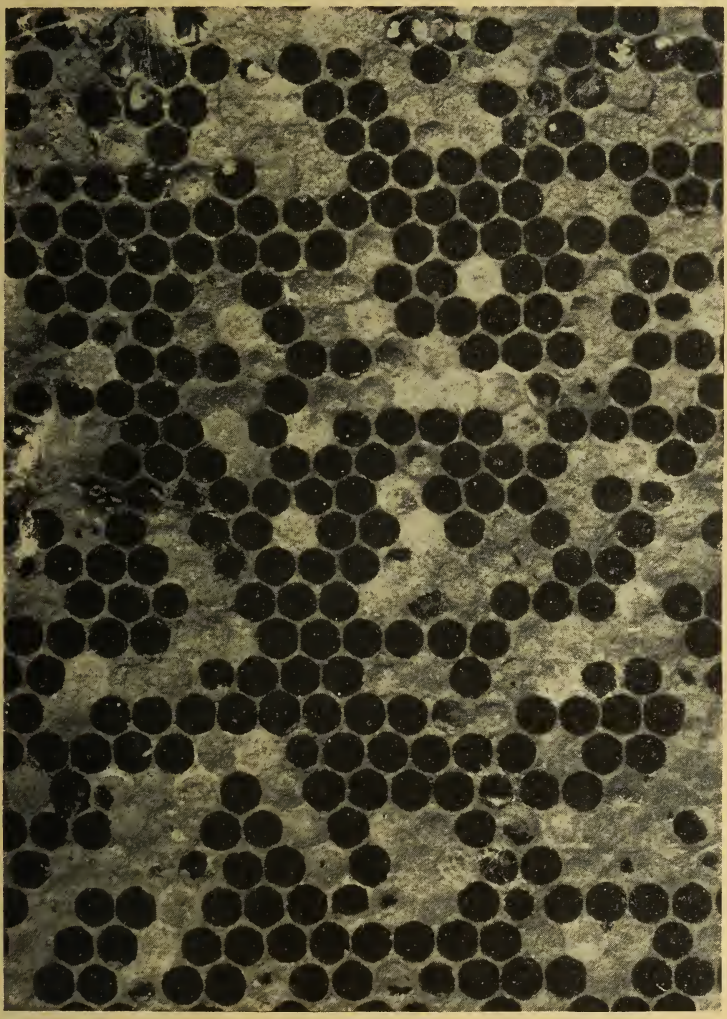

FIG. 2.—ADVANCED STAGES OF AMERICAN FOULBROOD

This frame was removed from the same hive shown in Fig. 1, July 20, 1919.

In American foulbrood there may be two or three very small punctures; and the cap may be gnawed but not entirely removed except in minute spots. In sacbrood the larvae observed soon after death have a slight yellowish tinge with the front end slightly darker. The back part of the body may remain yellowish for some time, and gradually become darker while the head portions turn almost black. Often the larvae, observed through the punctured cappings, appear brown with a reddish tinge. The body wall of the larvae does not break so easily as in the other diseases and the larvae may be removed from the cell intact. The body when ruptured appears as a granular mass with a more or less watery appearance. The larvae require a much longer time to dry down and the scales do not remain fast to the cell wall as in American foulbrood.

How the Diseases are Spread

Little is known about the method of spread for European foulbrood or sacbrood, but both of these diseases may appear suddenly in every colony in a yard. Package bees placed on empty drawn combs may develop the disease as severely as old colonies. In 1920, package bees shipped from Texas and placed on sheets of foundation developed both diseases between May 1 and June 1. The season of 1920 was favorable to these diseases and strong colonies suffered in the same proportion as weaker ones. European foulbrood disappeared as soon as the honey flow began, but the sacbrood did not disappear until the honey flow was nearly over.

The spread of American foulbrood[2] from one state to another, or over widely separated areas, is due to shipping diseased bees and infected equipment or honey.

Aside from buying diseased bees and bringing them into a disease-free territory, the buying of used hives and old combs is one of the most dangerous things a beekeeper can do. As a rule, beekeepers who have old hives or combs to sell without bees have lost their bees through disease. Old combs from such sources are almost sure to carry disease, especially if there is honey in them.

Old combs from a region in which foulbrood is known to occur should never be given to disease-free bees.

[2]Report of State Entomologist for 1917 and 1918. Bul. 20, Wis. State Dep't. of Agr.

Second hand hives and equipment should never be used without first scraping and washing them in hot lye water.

Spread of disease locally is caused by exposing infected honey to robber bees or through interchanging infected combs from diseased to healthy colonies. When the disease once appears in a yard, immediate measures should be taken to stamp it out. No risk however small should be taken by exposing a diseased colony to robbing; and diseased colonies should not be opened at all during brood rearing when bees are not able to gather nectar in the field. A single drop of honey taken from a diseased colony may be sufficient to carry the disease to a healthy colony.

After the honey flow, manipulation of diseased colonies should be left until late October when brood rearing has ceased. The danger is not so great then because the infected honey will nearly always be put in the center of the brood nest and will be consumed before the next brood rearing period begins.

Removal of Infected Honey and Combs Necessary

There is but a single principle involved in the eradication of American foulbrood. That is to destroy every living germ in a hive and eliminate all sources of reinfection.

A study of the conditions within a diseased colony shows that the adult bees are not affected, and that they do not carry the disease except in the distribution of honey which contains the bacteria or spores. When all germ-bearing honey and combs are removed from a colony of bees, the disease disappears.

A certain amount of diseased honey is carried by the bees in transferring them from the old combs to sheets of foundation, but apparently all of this honey is consumed during the first 24 to 48-hour period in the new hive.

A strong colony of bees when transferred to full sheets of foundation will, in less than 48 hours, draw out cells far enough so that the queen will lay eggs in them. They may also store small amounts of honey in cells surrounding the brood, but this honey is used up by the bees before the eggs hatch. This provides a period of at least four days for the entire consumption of the honey. Then for a period of three days, theoretically, the young larvae are not fed honey, but

FIG. 3.—ABANDONED APIARIES RESULTING FROM AMERICAN FOULBROOD

Neglect on the part of the poor beekeeper leaves such deserted apiaries as a menace to better beekeepers.

royal jelly so that their food is not subject to infection during that period except as the bacteria taken in with the food may remain in the mouth cavity of the nurse bee and become mixed with the larvae food. However, from the fact that the larvae do not show disease symptoms until after they have reached the end of the feeding stage, it is possible that infection does not take place until after the larvae are three days old. In this case there is an actual period of seven or eight days in which all of the diseased honey carried from the old brood chamber may be consumed. During this period, however, the bees will be bringing in food from the field and storing it in other parts of the hive as well as keeping a supply near the brood nest. If infected honey can be reached either in the store room or through exposed combs during the treatment of other colonies, reinfection may occur. The beekeeper then must carefully carry out every detail of the treatment and keep infected honey or combs in a tight storeroom.

No beekeeper who is careless or neglects to remove all infected honey or combs and keep them away from the bees can expect to eradicate disease from his apiary.

Why Extracting Frames Should Not Be Saved

Many beekeepers have attempted to save dry brood-free extracting combs thinking that unless brood had been reared in them they were free from disease. Brood-free extracting frames that are absolutely dry and free of small drops of dried honey do not carry the disease. Careful observations show that so-called dry combs are seldom entirely free from honey unless the colony from which they are taken has been brought near to the point of starvation.[3] If there is a fair amount of stores present in the brood chamber, bees clean up the extracting combs and usually—but not always—put the honey in a few cells. In many cases a very small amount may be left in a cell and over a long period of time, perhaps five or six months or from one season to another, these tiny drops dry out and form a very small scale which does not show in glancing over the combs. These small scales of dried honey may contain spores of the disease and when honey is again stored in these cells, the scales are softened and the spores liberated.

[3]Just how the honey in the extracting supers becomes infected is not clearly understood. During a heavy honey flow the bees deposit nectar in the brood chamber and later carry it to the supers—perhaps this is the explanation.

Where the honey from these cells is fed to the bees, a new infection is started which soon spreads to other parts of the brood nest.

In an experiment made in 1919, eight sets of "brood free" dry extracting combs taken from colonies diseased with American foulbrood were given to eight two-pound packages of bees. Sugar syrup was fed to these so that they had abundance of stores up to the time of the honey flow.

In six of these, disease did not appear at all during the season. In two others the disease appeared with the first set of brood and continued to increase until the colonies were treated in July. While only two of the colonies became diseased, the amount of disease carried was 25 per cent. Such a high percentage makes the use of dry extracting combs very dangerous.

FIG. 4.—AMERICAN FOULBROOD CAUSED A HEAVY LOSS IN THIS APIARY

In 1918 an average of 187 pounds of honey per colony was produced here. In 1919 nearly every colony was diseased and almost cleaned out due to the introduction of the disease in the fall of 1918.

Five sets of frames with foundation which had been worked on but slightly or not at all were also taken from diseased colonies of the year before and given to package bees. Sugar syrup was fed to these colonies until the honey flow began. No disease appeared in any of these colonies.

DOES SCORCHING INSURE COMPLETE DISINFECTION?

Bees do not leave honey scattered about on the walls of the hive or on frames and will immediately gather up the smallest

drop that may fall from a cell. Therefore, there is no more danger of the disease being carried on clean hive parts than on the body of the bee. If the disease is spread at all outside infected honey or combs, it would seem that the bacteria would adhere to the body of the bee and continue as a source of infection indefinitely, for we know that the spores of the bacteria may live over for several years. On the other hand, in every case where the diseased brood and infected honey is removed the disease is eliminated; and we must conclude that the bacteria are not carried over on the body of the bee. The same is true of hive bodies and frames—if they are absolutely free of honey the bacteria are not carried over on them.

In a large number of tests the hive body, bottom board and cover were taken from a diseased colony instead of from a clean hive. Clean frames with full sheets of foundation were used and the bees brushed on to them. The percentage of successful treatment was as large in every case as with scorched hive parts. The danger of using old hive bodies lies in carrying them over until the next season and not thoroughly cleaning them of drops of infected honey which may have gotten on to them after removal from the bees.

If all hive parts and frames are thoroughly scraped and washed with hot lye water so that all particles of liquid or crystalized honey are removed there is no danger of reinfection from this source.

Where a number of colonies are to be treated, hive bodies free of burr combs may be taken from treated colonies and used to shake other diseased colonies into if done at once.

Never use a hive body from a diseased colony on another colony having drawn combs without scraping and cleaning. Clean not only the inside of the hive but the outside and edges as well. Take special care to clean up all honey from behind the rabbets.

Scorching out the hive body is no safer than scraping and washing unless every inch of surface both inside and out is treated. Many beekeepers carefully scorch out the inside of the hive but overlook honey behind the rabbets or smeared on the outside of the hive.

Frames Should Be Saved

It is not economy to destroy the frames from diseased colonies except where one or two colonies out of a large num-

ber are affected and the beekeeper undertakes to stamp out the disease by destroying hive, bees and all. It is also unnecessary to scorch the frames but they must be scraped and cleaned of wax and honey. To insure the removal of particles of crystalized honey place the frames in boiling water for five minutes and dip in a second tank of boiling water. If the frames are loose a few extra nails will make them rigid.

WHY BEEKEEPERS FAIL TO ERADICATE FOULBROOD

1. Careless manipulation during the treatment.
2. Exposing diseased combs or honey to robbers.
3. Failure to remove all infected honey from the hive body or frames.
4. Failure to clean up the extractor or floor of the extracting house and storage room.
5. Leaving infected honey on the floor and then setting hive bodies in it after they are cleaned. The honey crystallizes and may remain on the hive body until put on a colony the following year.
6. Improper attention to hospital colonies such as leaving them exposed and treating after the honey flow is over. All hospital colonies should be treated before the end of the honey flow.

BRUSH BUT DO NOT SHAKE

Shaking bees from combs infected with foulbrood is a bad practice and is always likely to scatter diseased honey where bees from healthy colonies may gather it. It is possible to brush bees from combs without spilling a drop of honey. This requires but little more time than shaking. When bees are shaken out of a hive there is always some danger that stray bees carrying a load of honey may go into a neighboring hive.

Bees are attracted to loose honey wherever they find it even during a honey flow, and a few robber bees are always to be found in the yard during a heavy flow.

When the treatment is finished, burn the brush. A brush which has been used in the treatment of diseased colonies should not be used with healthy colonies. A whisk broom or a bunch of stiff grass—tied so that pieces of grass will not break off—is better to use than a brush having bristles that dip into the cells. If a whisk broom is used, get a soft one and cut out about one-half the brush part.

When and How to Treat

Do not treat bees by brushing unless there is sufficient honey coming in to keep bees from robbing. Diseased bees may be treated in the late fall after brood rearing has ceased by transferring to combs filled with uninfected honey.

Bees may be successfully treated during any period of a honey flow, but the most desirable time is shortly after the beginning of the main honey flow. This period for Wisconsin is June 15 to June 20. Diseased colonies found after the honey flow is over should be treated in late October after all brood rearing has ceased by transferring to combs of "disease-free" honey. If the operator is careful in transferring the bees at that time, robbers will get very little honey, and this will quite likely be put where the bees will use it during the winter.

FIG. 5.—THE BRUSHING TREATMENT FOR AMERICAN FOULBROOD.

Hive A is the foulbrood colony. B is the empty hive into which the brushed combs are to be placed.

Plan your work and have your hive bodies ready so that every diseased colony in the yard can be treated on the same or the following day. Melt up the combs and clean the hives at once.

The immediate removal of diseased combs and honey is the greatest insurance against reinfection. Do not store the hives over until next spring and do not bring a diseased hive or comb into the extracting house or storeroom reserved for disease free hives and supers.

If a colony is found diseased do not open it when no honey is coming in from the field. One of the most fruitful sources of infection is the exposure of combs containing infected honey or exposing diseased colonies to robbers. Colonies of bees vary greatly in the amount of robbing they do. Some colonies

are continually on the hunt for stores while others remain peacefully at home. Possibly the amount of stores has some effect but no difference has been observed here between colonies having abundant stores and those with small amounts. Diseased colonies that are weak at the end of the honey flow should be destroyed at once. As soon as the disease is found, close the hive, carry it into the cellar and destroy bees and combs immediately. Also see that none of the bees escape after they are in the cellar, for bees loaded with honey fly back to the old stand. When they do not find the old home, they will go to the nearest hive and be allowed to enter.

METHOD OF TREATMENT

Regardless of the plan to be used, the principle is the same in every case—removal of infected honey and disease bearing combs. After trying several methods of accomplishing this and observing the results, the following method seems to be the simplest and safest if carefully done.

1. Colonies that are known to be diseased should not be given extracting combs prior to the treatment. If colonies have been supered and the bees have built comb between the frames, lift off the extracting supers. Then starting with the one next to the brood chamber, draw a knife between each frame and separate it from the next. Do not do this until the super is placed back on the hive. The operator should carry a can of steaming hot water with him and drop the knife into the water while moving the supers. Be careful not to allow any honey to drop outside the hive. This operation should be done the day before treating so that the bees will clean up the edges of the comb. The job of treating will then be less messy and the chances of dropping honey outside the hive will be greatly reduced.

2. Select an empty hive body that is bee tight and nail a tight bottom to it. Then place a cover on it that can be moved freely back and forth when diseased combs are being put into it.

3. If the colony is only of medium strength, use one brood chamber with full sheets of foundation. With unusually strong colonies use two. Place an empty super on these to brush the bees into.

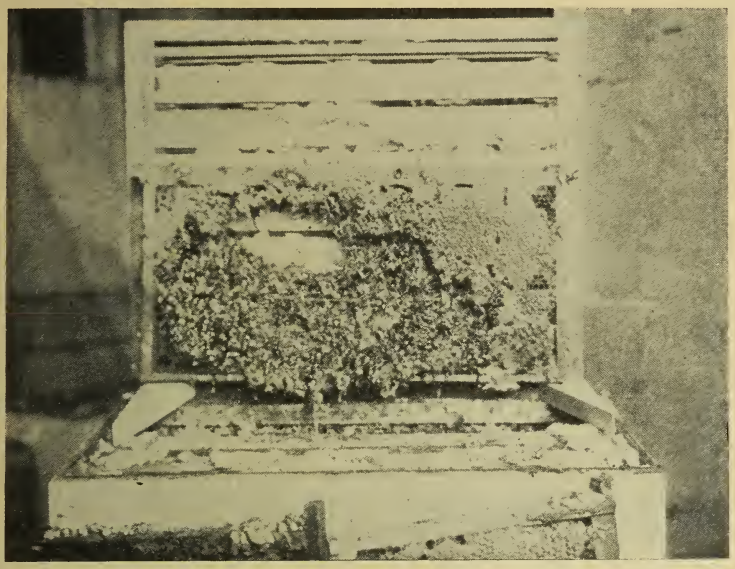

FIG. 6.—A SOURCE OF INFECTION FOR NEARBY COLONIES

After the bees died out from American foulbrood the wax moths entered and destroyed the combs in this hive. The honey which leaked out was a source of ready infection for healthy colonies.

4. Place the hive body which is to receive the diseased combs to the left and rear of the colony to be treated, and put the supers of foundation and empty super at the left of the diseased colony.

5. Now lift the diseased hive from the bottom board and place on a tight fitting board at the right of the old stand. Then place a queen excluding board on the bottom board still on the old stand and set the clean hives and super on top of the queen excluder. The excluder will help a great deal to keep the bees from absconding.

6. Slide the cover of the diseased colony slightly to one side. Then lift out a frame and stand it on top of one of the frames below the empty super into which the bees are to be brushed. The bees may then be brushed off, no honey will be thrown onto the frames and less honey will be carried into the new hive than when the bees are shaken from the frames. As soon as the bees are brushed from the comb, place it in the hive body at the left and cover.

If more than one hive body was on the diseased colony stack them one above the other with a bee tight board below and

the cover above. When the frames from one body have been removed, shift the empty body to the top of the hive body now holding the diseased combs and use it to hold the next set of frames.

7. As soon as a colony has been treated, remove all infected

FIG. 7.—DISEASE MEANS WASTE

In two years American foulbrood killed 120 colonies which had been producing annually 12,500 pounds of extracted honey.

combs to the storeroom before treating the next colony.

8. Do not wait until fall or winter to melt up the wax and clean the combs. Do it at once. Otherwise you are almost sure to have your yard accidentally reinfected before fall.

Even with the most careful treatment reinfection may appear in a few colonies either the same or following year. These should be treated or destroyed as soon as a few cells appear.

THE DOUBLE-SHAKE TREATMENT

Some beekeepers recommend the "double-shake method." The bees are first shaken onto frames with starters. After about four days these are removed and the bees shaken a sec-

ond time onto full sheets of foundation. This practically insures getting rid of the disease if no outside source of infection exists.

FIG. 8.—DISEASE WAS FORCED OUT

This apiarist cured 185 colonies of the disease and later had for sale 7,382 pounds of comb honey and 4,750 pounds of extracted honey.

Drawn Combs Used With Foundation

Among Wisconsin beekeepers there is a practice which is more or less doubtful as to success. When the bees are run onto full sheets of foundation, one frame at the side of the hive is left out and an old drawn comb is put in its place. The idea is that the bees store the honey they have brought with them in this comb and that by removing it the next or following day the infected honey will all be removed. The very fact that the bees store honey in this comb makes the practice dangerous. No matter how careful a beekeeper may be, he cannot open the hive and remove the comb without inciting a number of bees to gorge themselves with honey from this comb. Thus the period for using up the infected honey carried by the bees at the time of shaking has been reduced 24 to 48 hours. By that time cells will be sufficiently built out on the foundation for immediate storage of the honey carried from the old comb.

DISPOSAL OF HONEY AND BROOD FROM DISEASED COLONIES

If only one, two, or three colonies in a yard are found diseased it is better to destroy the brood at once by burning in a closed space of some kind. If a whole yard is to be treated, so-called "hospital colonies" may be made by stacking the combs from four or five colonies on top of a slightly diseased colony above a queen excluder until the brood is hatched out. Then the "hospital colonies" are treated and the brood combs from them are melted down or destroyed.

Hospital colonies kept around a yard are extremely dangerous and are likely to be a continual source of reinfection no matter how carefully they may be looked after.

Honey from such colonies should be extracted and bottled as soon as taken from the hive. All combs, including those with brood from the lower hive body of each colony, should be melted down and the wax extracted at once.

Hospital colonies should not be allowed to run longer than 21 days before treatment. The bees should be removed from the upper stories by means of a bee escape and the hive bodies removed and carried into the storeroom before treating the bottom part.

Hospital colonies should be set at some distance from the main yard and all hive bodies must be bee tight except for the entrance.

Hive bodies and hive parts from hospital colonies should be thoroughly scraped and cleaned before using on other colonies because during the period of treatment they are likely to be somewhat smeared with honey and it is almost sure to carry spores of the disease from these colonies.

THE BEEKEEPER HIS OWN INSPECTOR

Every person who keeps bees should frequently look through the brood nest of each colony to see that conditions are normal. If the appearance of healthy brood is well known, any abnormal condition will be easy to detect. If diseased or dead larvae are found, report the condition either to the local or state inspector.

A single diseased larva in the spring may result in a badly diseased colony in the fall. Such a colony may become weakened to the extent that it is robbed out and the disease scattered to many colonies in the yard.

In exceptional cases, very strong colonies are able to overcome a slight infection; and it is not unusual to find colonies in which the disease continues but does not seem to make much progress during any one season.

Cases of this kind are very rare but the danger of spread is so great that these colonies should be treated the same as other diseased colonies. Treat your own bees as you would wish your neighbor to treat his if his apiary were diseased and yours were clean.

How to Ship Samples of Infected Comb

When selecting a sample to send in for examination, be sure to get a piece of comb three or four inches square. Do not pack in a tin or paper box but use wood. A small cigar box is good.

Co-operate with your neighbor beekeeper and his neighbor beyond to locate the disease in every infected apiary. Help wipe out foulbrood by cleaning up your own yard if it is diseased. Organize a local clean-up campaign to drive the disease entirely out of your county.

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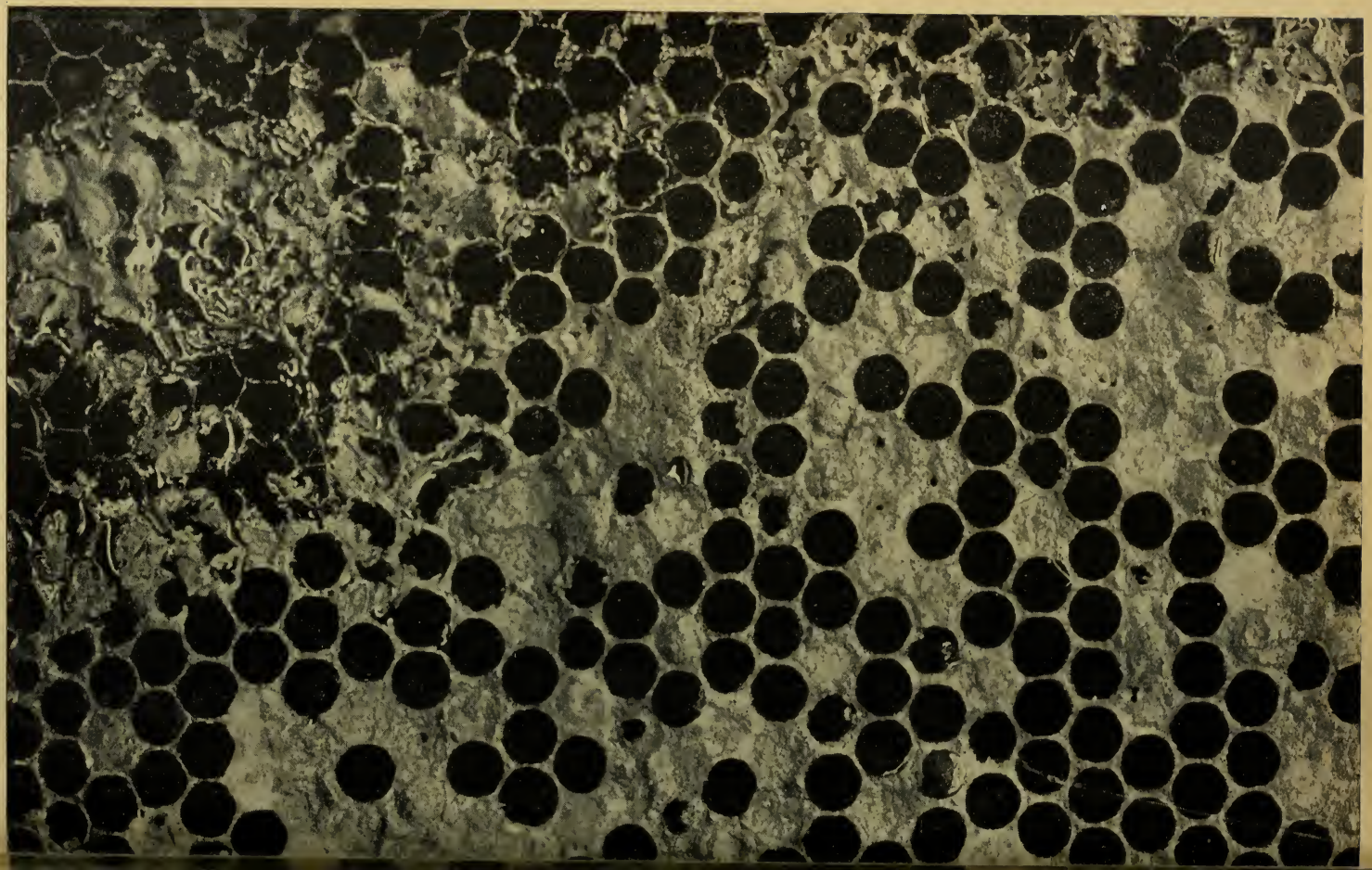

Bulletin 334 July 1921

AUG 3

COMBAT POTATO LEAFHOPPER WITH BORDEAUX

WHEN YOU DO

WHEN YOU DON'T

AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF WISCONSIN
MADISON

Cooperating With the United States Department of Agriculture

DIGEST

The potato leafhopper is a deadly menace to the potato crop in the Middle West and East. Page 3

The insects are very small but often occur in vast numbers and in feeding rob plants of much of their sap. Page 7

Hopperburn may result in large losses to potato growers. This is a diseased condition of the foliage caused by the leafhopper. Page 7

Early Triumph potatoes are much more severely affected with hopperburn than are Rurals and other Wisconsin potatoes. Page 14

Hemp, sugar beets, nursery apple trees, soy and garden beans are injured by this pest and hopperburn. Page 18

Bordeaux mixture will control the leafhopper and hold hopperburn down to a point where it causes no appreciable loss. Pages 23-29

Spraying greatly increases potato yields if it is done early, often, and thoroughly. Page 28

Combat Potato Leafhopper with Bordeaux

J. E. Dudley, jr.,* and H. F. Wilson

The potato leafhopper is one of the most important enemies of the potato in the United States.

Serious outbreaks have occurred periodically in certain sections of the United States since the early eighties, but not until 1896[1] was the leafhopper known as a dangerous menace to the potato crop in the Middle West and East. It attacks a large number of plants and occurs commonly on the apple, the plant from which it was first described.[2] The leafhopper sucks the juices from the plants so that the foliage turns yellow and the leaves curl and wither. Under ordinary circumstances this is not serious but another injury accompanies the feeding of the leafhopper and causes the rapid death of the plant if nothing checks its spread.

A diseased condition is produced in some manner in the plant which causes the foliage to blacken and die. The cause of this is not well understood, but the indications are that a toxin, or possibly a disease, is transmitted through the feeding punctures of the leafhopper and that the effect spreads rapidly to all parts of the plant.

The disease itself has not been studied, but many observations upon the spread of the injury and the gross effect upon the plant have been made to learn the conditions under which the injury develops.

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*The senior author, J. E. Dudley, Jr., scientific assistant on the staff of the Bureau of Entomology of the United States Department of Agriculture, is in charge of a field station at Madison, Wisconsin, where most of the experiments described in this bulletin were carried out in co-operation with H. F. Wilson of the Wisconsin Agricultural Experiment Station.

[1]Osborn, Herbert. A New Pest of Potatoes. Iowa Expt. Sta. Bul. 33. 1896.

[2]*Empoasca mali.* This species has been called the apple leafhopper in many publications for the past fifty years. In order to distinguish it from the true apple leafhopper *(Empoasca unicolor)* the name of its principal host, the potato, has been used for its proper common name.

Seasonal History is Important

The potato leafhopper (Fig. 1) lives over winter in the adult stage, hidden away in brush heaps, matted weeds, and other protected places. In late May or early June the "hoppers" emerge from their winter quarters, feed for a week or ten days on trees and shrubs, then suddenly migrate to potatoes and beans where mating and egg laying begin. During the first week after emergence in the spring, the females greatly outnumber the males often by ten to one.

FIG. 1.—ADULT POTATO LEAFHOPPER
Enlarged 20 times.

Eggs — Tiny, transparent, very delicate eggs, about $\frac{1}{30}$ of an inch in length are inserted by the female into the midrib and stem of the potato leaf. (Fig. 1-A and Fig. 2-A). The eggs cannot be seen from the outside and careful dissection of the midrib is necessary to disclose them. During the incubation period the eggs change from transparent white to yellow. Two red spots, the eye of the developing leafhopper, appear. Under artificial conditions eggs hatch in from 9 to 11 days into young leafhoppers called nymphs. Under field conditions the incubation period appears to be somewhat longer.

Nymphs—Newly-hatched nymphs are very small, wingless, and nearly white. They start at once to suck juices from the plant and gradually turn yellow, then greenish in color. They pass through five distinct stages or periods of growth, and shed the skin at the end of each stage. (Fig. 2, B to F). When quite young the nymphs move around but little and are nearly always found on the under side of the leaves. When disturbed, however, they move quickly to the top of the leaf going sidewise like

a crab. During the fourth and fifth stages, (Fig. 2, E and F) they are more active and frequently hop from leaf to leaf. At this time, they are quite green and the partially developed wings are easily seen at the middle of each side of the body. An average of 17 days is required from the hatching of the egg until the adult stage is reached.

Adults—The full grown leafhopper is a small pale-green insect about ⅛ of an inch long, with thin irridescent wings, large white eyes and a more or less distinct H on the thorax. (Fig. 2, G) There are six roundish white blotches at the top of this H and three white, wedge-shaped blotches below it. These marks serve to identify the insect.

FIG. 1-A.—TINY TRANSPARENT EGG OF LEAFHOPPER LAID IN STEM OF BEAN PLANT

Enlarged 6 times.

Two Generations in Wisconsin—Two generations of the insect are produced in one summer. Most of the over-wintered adults have died off by the middle of July while their young develop into adults and form one complete generation appearing about the last of July. A second generation is then developed. The young pass through the same stages as the first generation although in a slightly shorter time, and a new brood of adults begins to appear about September 1. This brood lives over winter. Many careful tests have shown that this second generation does not reproduce until the following summer.

Although the appearance of adults of each summer generation is limited to two distinct periods of about two weeks each,

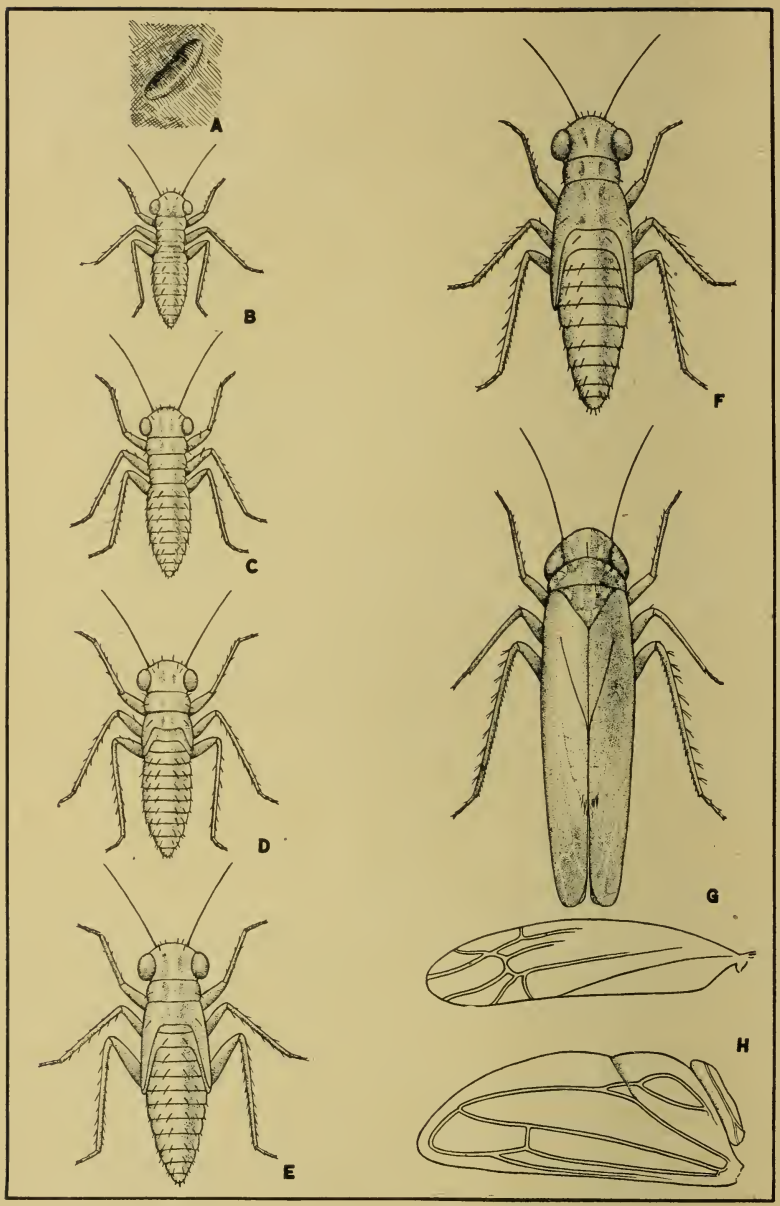

FIG. 2.—THE POTATO LEAFHOPPER

A. Egg in leaf tissue; B. first nymphal stage; C. second stage; D. third stage; E. fourth stage; F. fifth stage; G. adult stage; H. outer (elytron) and inner wing, showing venation.

the females have a long egg-laying period and it is possible to find nymphs in all stages from the last of June until well after frost in the fall.

How the Potato Leafhoppers Feed

Adults and nymphs of the potato leafhopper, like other leafhoppers, suck the juices or sap of plants through their delicate beaks which they insert through the epidermis of the leaf. In contrast to certain other leafhoppers, however, the potato leafhopper appears to feed only on the larger veins in the upper half of the leaf and not on the small veinlets. This affects the supply of sap while it is being distributed to the leaves so that the entire portion of the leaf supplied by the vein attacked is indirectly affected.

Plants Injured by Loss of Juices

The amount of plant juices lost through the feeding of any of the different kinds of leafhoppers is dependent upon the size and abundance of the insects. The injury which follows normally appears either as a yellowing or curling of the leaf which is sometimes sufficient to kill individual leaves but seldom the entire plant.

Potato Leafhopper Causes Distinct Injury

Close observations on injured plants have shown that the potato leafhopper is the cause of a distinct injury which follows its feeding on potatoes and several other plants. This distinct injury is called *hopperburn*[3] and begins with a slight yellowing, usually at the tip of a leaf. Later, as the injury progresses, the leaf turns brown, curls upward and withers. (Fig. 3.) The disease spreads from the tip or margin toward the midrib of the leaf, but spreads more slowly towards the base. The basal area of some leaves may remain green until the whole plant is nearly dead.

During periods of hot, dry weather, hopperburn spreads rapidly and whole fields of early potatoes may be killed in a week. (Fig. 4.) On the other hand, during cool, moist weather, or where protective sprays have been applied, hopper-

[3]Ball, E. D. The Potato Leafhopper and the Hopperburn That It Causes. Wis. State Dept. of Agri. Bul. 20, pp. 78-89, 1918.

FIG. 3.—HOPPERBURN ON POTATO LEAF

Photograph from upper surface showing typical brown, upcurled tip and margin. (Enlarged 4 times.)

burn is checked and throughout the summer shows nothing more than the primary symptoms.

Although hopperburn is communicated to the plant when the leafhopper feeds, it may also follow when the female inserts her eggs in the midrib or stem of the leaf. During the growing season of the potato, the injury always appears first on the lower leaves and gradually spreads to the upper ones. This is explained by the fact that nymphs tend to remain in the vicinity where they hatched until the adult stage is reached. New growth

is at first comparatively free of them but gradually becomes affected through feeding of the ever moving adults.

Leafhopper Proved to be Responsible for Hopperburn

In order to prove conclusively that the potato leafhopper is responsible for the transmission of hopperburn to potato and other plants, tests were made in the insectary with individual screened plants in pots and in the field with plants covered with large cages.

Tests with potatoes—In two tests in which a single adult "hopper" was placed on each plant, marked symptoms of hopperburn appeared in five days and progressed until in 16 days both plants were dead while two plants kept free of "hoppers" remained healthy throughout the test.

FIG. 4.—POTATO PLANT HALF DEAD FROM HOPPERBURN

During hot, dry weather whole fields may succumb to this injury in a short time.

In other tests where a number of adults were placed on potato plants, hopperburn appeared in from 10 to 21 days.

FIG. 5.—TWO APPLE SEEDLINGS SHOW EFFECT OF PRESENCE AND ABSENCE OF LEAFHOPPER.

Tests with beans—Two leafhoppers were placed on each of four potted bean vines. In less than two weeks all the vines became severely injured and three died. Vines kept free of "hoppers" remained healthy throughout the test.

Tests with apple—Two apple seedlings were growing in a flower pot. Four nymphs were confined in a cage on one seedling which in ten days became badly injured, while the other seedling free from "hoppers" remained healthy throughout the summer. (Fig. 5.)

In another test several small nymphs were placed on an apple seedling for some time but no injury appeared. Some weeks later two adults were placed on the same plant and following hopperburn injuries it died in two weeks. Adults taken from the field and placed on other seedlings produced the disease in from 10 to 21 days.

Tests with dahlia—Twenty newly-hatched nymphs were placed on a large, healthy dahlia plant. In seven days the plant was diseased and in 20 days was dead. A potted plant kept free of "hoppers" did not show injury and was still healthy at the end of 20 days. (Fig. 6.)

Although the typical injury did not appear in every test where leafhoppers were placed on food plants in pots—especially where nymphs were used—yet in a large majority of tests well developed symptoms of hopperburn were noted. It is certain then that even one or two leafhoppers are able to cause injury to a plant often to the extent of killing it. Males as well as females were found to cause the injury.

FIG. 6.—DAHLIA PLANTS READILY AFFECTED BY HOPPERBURN

The two plants were of equal size when the test started. The one on the left contained leafhoppers; the one on the right was protected from them by a large cage.

Field Tests

In order to carry out similar tests under field conditions, the following experiment was conducted: On June 12, 1920, when potatoes were breaking through the ground, large cages covered with fine mesh wire were placed over two hills of each of the following varieties: Early Triumph, Early Ohio, Irish Cobbler, Green Mountain and Rural New Yorker. These plants, protected by cages (Fig. 7) grew faster than plants in the rest of the field until, by the latter part of July, they were twice the size of unprotected plants. By the middle of August, however, the uncovered plants overtook the caged ones.

On July 12 fifteen adult leafhoppers were placed in one of the two cages over each variety. In each cage they reproduced so that in a short time there was an abundance of nymphs.

In the Triumph cage hopperburn appeared on July 21, or nine days after the "hoppers" were introduced. The disease spread steadily and in 23 days the plants were dead. The plants not subjected to leafhopper attack remained entirely healthy up to September 2 when they were dug. (Fig. 8.)

In the Early Ohio cage, hopperburn developed in two weeks after the "hoppers" were introduced, the plants dying late in August. Protected plants remained healthy all season.

Hopperburn appeared in the Irish Cobbler cage two weeks after the "hoppers" were introduced. By the first of September the plants were badly diseased and nearly dead, while the protected plants were fairly healthy.

In the Green Mountain cage hopperburn did not appear until July 29, or 17 days after "hoppers" began to attack the foliage. By September 9 the plants were affected with "burn" to a moderate degree. Plants protected in another cage had no hopperburn.

FIG. 7.—CAGES USED IN HOPPERBURN TESTS

In these tight cages some plants were protected from hopper attack all season. Hoppers were placed in other cages and produced hopperburn.

FIG. 8.—ABSENCE OF HOPPER MEANS NO HOPPERBURN

Triumph potatoes caged for entire season. Leafhoppers introduced into one cage and kept out of other. 1920 experiment.

Hopperburn did not appear on Rural New Yorker foliage until August 3, or 22 days after introducing the 15 "hoppers" although there had been adults and numerous nymphs present right along. After starting, however, the disease progressed rapidly, and the plants were dead the first of September. The protected plants were perfectly healthy at this time.

Incidental observations regarding hopperburn were valuable. Numerous potato flea beetles and potato aphides were found in all cages, both those containing leafhoppers and those kept free of them. As the disease did not occur in cages protected from

the "hopper," it is quite indicative that these two insects do not transmit hopperburn.

Relation of Leafhopper to Hopperburn in the Field

During visits to potato growing sections of the state, it was observed that without exception, when the injury was found the potato leafhopper was always present, and no injury was present when leafhoppers were not found. The extent of hopperburn as affecting both individual plants and whole fields, was in close proportion to the number of leafhoppers present.

Several examples may be given: A field of Green Mountain potatoes on new land surrounded by woods was visited in August. It had not been sprayed. At first glance, the field appeared uninfested by insects. However, upon closer examination a leaf here and there was found which showed symptoms of the injury. Without exception, a leafhopper or cast skin could be found on or near every leaf thus affected.

In a field of Early Triumphs a fourth of a mile away, the amount of hopperburn was found to be much greater than in the field of Green Mountains. Likewise, the number of leafhoppers was much larger.

In a field of late planted Rural New Yorker potatoes neither leafhoppers nor hopperburn injury was found. An adjacent field of early potatoes was heavily infested and badly injured.

Hopperburn More Severe on Certain Varieties

Different varieties of potatoes are attacked to a different degree by the potato leafhopper, and different varieties are affected to a different degree by hopperburn.

The extent to which the same varieties are affected has appeared to be much the same at widely separated points in the state. The Early Triumph variety is always affected worst, the Rural New Yorker variety always least, and, moreover, the Rurals are always attacked most lightly by the leafhopper. The relative number of leafhoppers on other varieties varies considerably.

It is believed that the leafhopper has a preference for certain varieties of potatoes of tender foliage and that these same varieties

may be more susceptible to hopperburn than sturdier varieties with hardier foliage.

Some Plants Are Resistant to Hopperburn

Observations for two seasons indicate that certain plants of a given variety have greater resistance to the leafhopper and hopperburn than have adjacent plants of the same variety. During the summer of 1919 in an unsprayed plot of Rural New Yorker potatoes, three plants although continually infested, remained practically uninjured, while the surrounding plants without exception became badly affected. The same was true to a greater or less degree with other varieties.

In order to test the resistance to hopperburn of individual plants of each variety, seed potatoes were selected in 1919 from Early Ohio, Irish Cobbler, Green Mountain, Rural New Yorker and Late Puritan plants. Two kinds of tubers were chosen at digging time from 12 vines of each variety; those from the six largest and greenest vines most free from hopperburn, and those from six vines which had been the first to die from the effects of hopperburn. The size of the tubers was not regarded in this selection.

In 1920 a plot of ground was set aside for this experiment and one row planted to each variety of the selected tubers. The north half was given over to tubers from the healthy vines of the year before; the south half was planted to tubers from the diseased vines of the year before.

A row of Wisconsin certified Early Triumph seed was planted as a check. The plot was sprayed four times with bordeaux mixture, 4-4-50 combined with lead arsenate, 2½-50.

An area of six feet across the extreme north end and extreme south end was reserved as a check and not sprayed.

Rurals—During most of the summer the foliage of plants from seed of diseased vines was heavier and more abundant than foliage of plants from seed of healthy vines. By the last of August there was little difference. The infestation of leafhopper adults and nymphs was slightly greater on plants from seed of diseased vines throughout most of the season. These plants became affected with hopperburn about the middle of July. It spread slowly the remainder of the season until at

digging time it was rather severe. Practically no "burn" occurred on the plants from seed of healthy vines until the latter part of August.

The amount of foliage and infestation on the two kinds of check plants was much the same as with the treated plants. The hopperburn, however, was much more severe on the plants from seed of diseased vines than on the others.

Green Mountains—Plants from seed of diseased vines had more foliage than plants from seed of healthy ones until the middle of August when conditions were reversed. The infestation of adults and nymphs also was greater on plants from seed of diseased vines until mid-August when it became greater on the others. Hopperburn occurred on both kinds of plants and increased gradually during the season. It was always more severe on plants from seed of diseased vines, especially during the latter part of August.

The amount of foliage and infestation on the two kinds of check plants was much the same as on the corresponding treated ones. Hopperburn, however, was much more severe on plants from seed of diseased vines.

Early Ohios—As with the two former varieties, plants from seed of diseased vines had more foliage than plants from seed of healthy ones up to the middle of August when they were practically dead. Plants from seed of healthy vines although severely affected with hopperburn lived two weeks longer. The infestation of adults and nymphs was a little greater on plants from seed of diseased vines. Hopperburn occurred on both kinds of plants in nearly equal severity up to August 10. From then on it was far worse on plants from seed of diseased vines.

Conditions of leafhopper infestation and foliage on the two kinds of check plants corresponded closely to conditions on the treated ones. "Burn," however, was more severe on check plants from seed of diseased vines.

Irish Cobblers—The foliage of plants from seed of healthy vines was more abundant from the first than the foliage of plants from seed of diseased vines and lived two weeks longer. The infestation of adults and nymphs was generally much heavier on plants from seed of healthy vines in contrast to any other variety. Hopperburn, although prevalent all season on both kinds

of plants, was much more severe on plants from seed of diseased vines.

More nymphs occurred generally on check plants from seed of diseased vines, and hopperburn was much worse on them than on check plants from seed of healthy vines.

Late Puritans—Foliage of plants from seed of healthy vines was much more abundant throughout the season than that of plants from seed of diseased vines. There was practically no difference in infestation of leafhoppers between the two kinds of plants. No hopperburn occurred on plants from seed of healthy vines until mid-August and it never became severe. On the other plants it appeared late in July and became severe by September.

There were always more nymphs on check plants from seed of diseased vines than on the others. "Burn" also was more severe on them and increased rapidly until in September it was very heavy. At this time "burn" was moderate, on check plants from seed of healthy vines.

The check plants of all varieties showed far greater difference in individual resistance to hopperburn than did those which were sprayed. The check plants coming from seed of the healthiest vines the year before held up much better under leafhopper attack and hopperburn, than did check plants from seed of diseased vines of the year before.

Although this experiment shows that certain plants have considerable more resistance to hopperburn than others of the same variety, a warning should be given. It is just as important to select according to the size and abundance of seed as to consider the health of the vines. It was found at digging time that many of the plants most resistant to hopperburn produced many small, inferior tubers.

Conclusions—For four out of five varieties, leafhoppers were found in greatest numbers on the plants which had the most abundant foliage during all or part of the summer. On the other hand, hopperburn without exception was worse on plants from seed of diseased vines whether or not they had the most abundant foliage. This was especially noticeable in the checks. It promises to be of interest to find the relation of plants seemingly preferred by the leafhopper and plants seemingly resistant to disease to their relative yield.

Soil Moisture May Affect Hopperburn

Hopperburn appears and spreads quite rapidly during hot, dry weather; and there are indications that the soil moisture available for potato plants exerts much influence upon the amount of "burn" likely to occur. With an equal abundance of leafhoppers it is believed that hopperburn would be far less serious in years when there is ample rainfall during the growing season than in dry seasons.

Potato Leafhopper Visits Many Plants

A large number of plants are visited by this leafhopper. In the order of greatest injury from hopperburn they are: Potato, bean (pole, string, navy, lima), hemp, beet (sugar, table), apple, raspberry, red clover, Swiss chard, strawberry, soybean, cucumber, rhubarb, lettuce and the hop tree. Among flowers and trees the following are visited: Dahlia, hollyhock, syringa, weigelia, sumac, dandelion, elm, box-elder, burdock, Indian currant and rose.

Although many of the above plants are used merely for feeding or even resting, reproduction is known to occur on potato, beans, hemp, apple, dahlia, and box-elder. Potato, without a doubt, is the favored host for reproduction with bean a close second. Hemp, sugar beet and apple (nursery stock or water sprouts) are more heavily infested with "hoppers" when growing near patches of potatoes or beans. Under such conditions reproduction takes place readily on them.

It was formerly known that hopperburn occurred on potato, beans, apple, raspberry, box-elder and dahlia. Additional plants recently found affected are beans (all varieties mentioned above), sugar beets, hemp and hollyhock.

Beans Severely Affected by Hopperburn

String and pole beans are as readily attacked by the potato leafhopper and as severely affected with hopperburn as are potatoes. Navy and lima beans are rather free from leafhopper attack and hopperburn. String beans in many parts of the state have been severely injured and the yield greatly reduced. A large field of pole beans heavily infested by the insect became diseased to such an extent that no pickings were made. Sprays had not been applied.

Observations were made on a large patch of beans of four varieties: Navy, string, bush lima and pole. Four applications of bordeaux mixture combined with lead arsenate were made

FIG. 9.—LEAF OF SUGAR BEET AFFECTED WITH HOPPERBURN
Brown, curled-up tip and margin of smaller leaf shown by arrow.

during the season. Pole beans were most heavily attacked by the "hopper" and suffered most from "burn" just when the pods should have been developing. String beans suffered next to the pole variety although a good crop of pods developed. Navy beans were not affected severely by hopperburn. Bush limas were practically uninjured. Very few adults or nymphs could be found on them at any time and no "burn" appeared until late in the season. A nearby field of soybeans was watched for comparison with the other varieties. No sprays were applied. The infestation of adults and nymphs was light at the beginning of summer and increased slowly until September. It never became heavy. Hopperburn was at all times light.

Sugar Beets May Suffer

The potato leafhopper will attack sugar beets in the early summer and reproduce thereon to some extent, but until nearby potatoes are dead the infestation is not heavy nor is hopperburn severe. A large field of sugar beets 200 yards distant from potatoes was found early in July to be lightly infested with adults and nymphs. Typical symptoms of hopperburn were evident. (Fig. 9.) This field remained lightly infested the rest of the summer and "burn" never became severe.

Another field observed joined a large patch of early potatoes just about dead from hopperburn. Leafhoppers were migrating in vast numbers from the potatoes to the beets. The first few rows of beets (next the potatoes) were very heavily infested with leafhoppers in all stages. Farther in, their numbers became steadily less until near the other side of the field the "hoppers" were few in number and well scattered. Hopperburn although not severe at this time was much heavier in the rows adjoining the potatoes than in the rows on the other side.

Natural Enemies Not Important in Control

Three enemies known to attack the potato leafhopper were observed during the season 1919. One, a tiny, wasp-like parasite, breeds in the leafhopper eggs. This parasite is general in southern Wisconsin, but does not occur in sufficient numbers to materially reduce the number of "hoppers."

Another enemy, a fungus disease, attacks both adults and nymphs. It was common all over the state in 1919, but apparently killed the greatest number of leafhoppers in the northern potato-growing sections. Warm, moist weather appears to be necessary for the rapid spread of the fungus. Leafhoppers affected with the disease soon die and turn from green to yellowish in color. In a short time a heavy fungus growth appears on the insect's body. (Fig. 10.) The fungus grows until the body is entirely enveloped in it and a striking blue and green irridescence appears, making the disease easy to recognize.

Spiders frequently catch and kill young nymphs or even adult leafhoppers.

Neither the parasite nor the fungus disease was found during the season of 1920. Although the parasite was no doubt present

in small numbers, no specimens were secured. The fungus disease was looked for in several potato sections of the state but weather conditions were not right for its best growth.

Bordeaux Controls Leafhopper and Prevents Hopperburn

Proper application of the spray is perhaps the most important feature in controlling the potato leafhopper. It *must* be applied

FIG. 10—ADULT POTATO LEAFHOPPER KILLED BY A FUNGUS.
During warm, moist weather this fungus may spread rapidly and greatly reduce the number of hoppers. (Enlarged 11 times.)

to the under side of the leaves and may well be applied *also* to the upper surface. The spraying must be thoroughly done, covering practically all of the foliage on the under side.

A high pressure (150 pounds, at least) should be maintained in order to cover the leaves with a fine mist, rather than with a coarse spray. Even with a hand-spraying outfit (Fig. 11) at least two adjustable angled nozzles on adjustable arms or booms (Fig. 12) should be used. Both sides of every row of plants can then be sprayed. If larger machines are employed, more rows may be sprayed at one time. A pressure gauge should be used on all pressure sprayers so that the operator may know whether or not the pressure is up to 150 pounds.

Spray Early—At least three applications should be made.[4] The first spray should be applied about the middle of June or when leafhoppers appear in numbers. It is often possible to time

FIG. 11.—AN EFFECTIVE TYPE OF WHEELBARROW SPRAYER FOR SMALL PATCHES

This sprayer has a capacity of 12 gallons. A pressure of 150 pounds can be kept by using two nozzles. Spray can be seen coming from the nozzles on the right.

this spraying so that with an arsenical added, the Colorado potato beetle also may be controlled.

The second spray should be applied in from ten days to two weeks from the first. The potato plants are growing rapidly at this time and offer new foliage to leafhopper attack. Frequent rains may be expected which wash off much of the material. Therefore, the second application should be timed accordingly.

The third spray should be applied about two weeks after the second, depending upon the following conditions: If new growth is infested by leafhoppers; if there is an abundance of leafhoppers in field; if the weather is hot and dry. (Hot, dry weather is very favorable to rapid spread of the injury.)

A fourth spray might well be given to advantage from the first to tenth of August when some of these conditions exist: A hot dry summer; heavy, new growth in late summer, or great abundance of leafhoppers in field.

[4]It is preferred not to give exact dates, because the time of spraying is bound to vary in different parts of the state.

Experiments Show Value of Sprays—Four plots were used for treatments in 1919 and three in 1920. It was thought necessary to have the plots widely separated in order that the treatment for one should not in any way affect another, especially as swarms of leafhoppers might be driven by the spray from one plot to another. In having the plots at considerable distances

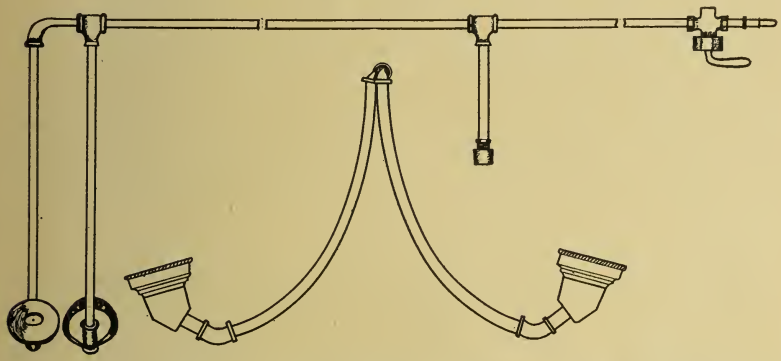

FIG. 12.—ADJUSTABLE SPRAY BOOM USED IN LEAFHOPPER EXPERIMENTS.

The boom may be adjusted in three ways: first, by bringing the arms together or spreading them apart which simply loosens or tightens the threads of the coupling; second, by turning the 45″ couplings just below the nozzles; and third by turning the angled nozzles themselves.

from each other, it was not possible to secure uniform growing conditions as to slope, fertilizer or character of soil. The best spray used therefore will be indicated principally by the amount of feeding injury and disease present on the foliage during the summer and not alone by relative yields.

EXPERIMENTS IN 1919

Bordeaux Mixture Proves Most Practical

One plot of Rural New Yorker and Green Mountain potatoes was sprayed four times with bordeaux mixture, using 4 pounds copper sulphate and 4 pounds unslacked lime to 50 gallons of water.

There was a moderate infestation of adults and nymphs in this plot when the first spray was applied but it gradually decreased up to the middle of July. From then to the end of the summer, there was a remarkable scarcity of both adults and nymphs especially on the Rurals. Newly-hatched nymphs appeared every day but disappeared in a short time.[5] Untreated

[5]Fluke, C. L., Jr.—Does Bordeaux Mixture Repel the Potato Leafhopper? Jour. Econ. Ent. Vol. 12, No. 3, pp. 256, 257—1919.

rows of each variety between the treated rows were heavily infested with the adults and nymphs throughout the summer.

Hopperburn appeared on tips of leaves scattered all over the plot after the second spraying and before nymphs began to hatch. On the Rurals it remained without spreading to any extent up to harvest. On the Green Mountains it spread very slowly and at digging time had not become serious—that is, probably not more than one-fourth of any plant had dead leaves. (Fig. 13.)

On the untreated rows the injury spread without interruption from the tip along the margin and to mid-rib and finally to the entire plant. At digging time, Rurals showed some injury on every leaf; Green Mountains were badly affected and many plants were dead.

FIG. 13.—TYPICAL CONDITION ON SEPTEMBER 5 OF PLOTS TREATED WITH BORDEAUX MIXTURE

The vines were heavy and in fair condition. The yield was greater than that from untreated plots. 1919 experiments.

Bordeaux Mixture and Nicotine Sulphate Give Effective Control

Two adjacent plots of equal size were planted to six varieties of potatoes—Early Triumph, Early Ohio, Irish Cobbler, Green

FIG. 14.—PLOT SPRAYED WITH BORDEAUX-NICOTINE REMAINS HEALTHY AND YIELDS HIGH

On August 23 the six varieties of potatoes were in good condition. Compare with Fig. 15. 1919 experiments.

Mountain, Late Puritan and Rural New Yorker. One plot was given maximum protection by being sprayed five times with bordeaux mixture, combined with nicotine sulphate for the last two treatments (6 fluid ounces to 50 gallons of bordeaux). The other plot received no protection from the leafhopper. A very heavy infestation of "hoppers" and frequent rains seemed at the time to require the five sprayings if maximum protection was to be given. It is probable that four applications would have been sufficient.

When the first spray was applied, leafhopper adults and nymphs were present in the treated plot in from moderate to large numbers. By the middle of July, however, a great decrease in their numbers was noticed. A week later, practically no nymphs and only an occasional adult could be found on the sprayed plot. This condition continued up to digging time.

The unsprayed plot was at all times rather heavily infested with both adults and nymphs and the numbers increased as the season advanced.

The treated plot immediately adjacent to a continual source of leafhoppers remained in excellent condition throughout the summer, the Early Triumphs being the one exception.[6]

A slight amount of hopperburn appeared on the tips of scattered leaves in the plot early in the season, but did not spread noticeably all summer, even during a period of hot, dry weather.

FIG. 15.—PLOT NOT TREATED IS BADLY DISEASED ON AUGUST 23

This plot next to the treated plot shown in Fig. 14 is seriously affected with hopperburn. Early varieties in the center are dead. 1919 experiments.

On Late Puritans and Rurals there was almost no injury. On the remaining varieties it was generally light. (Fig. 14.)

The untreated plot showed first signs of the injury early. In contrast to the treated plot the injury spread rapidly until midsummer, at which time the early varieties were practically dead and the late badly affected. (Figs. 15 and 16). The Rurals showed less injury at digging time than any other variety.

Thus the plot given maximum protection showed a considerable beneficial contrast to the plot given no protection.

Nicotine Sulphate Alone Does not Control Hopperburn

One plot of Early Ohio and Rural New Yorker potatoes was sprayed four times with nicotine sulphate and fish oil soap (using 6 fluid ounces of nicotine and 2 pounds of soap to 50

[6]The Early Triumph seed came from vines which had been killed the previous year by hopperburn. Both sprayed and unsprayed vines became seriously affected with hopperburn early in the season and were dead by the middle of July.

gallons of water.) Four applications were necessary because of the enormous number of leafhoppers present and the hot, dry weather. The treatments did not noticeably reduce the infestation of adult hoppers so that the eggs were laid right along and young nymphs appeared without cessation. Nymphs present when the spray was applied were readily killed, but no repellent effect

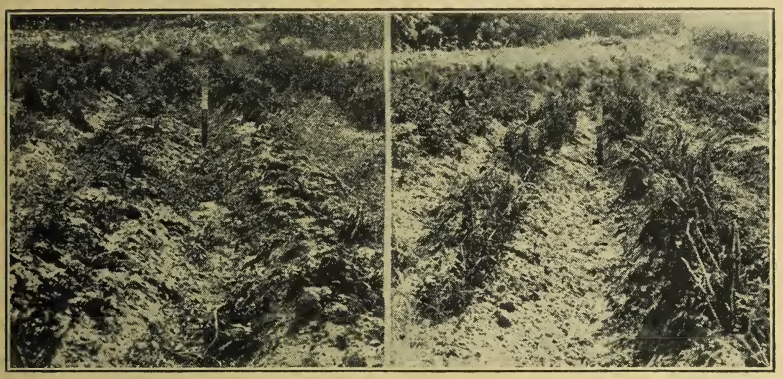

FIG. 16.—TYPICAL CONDITION ON SEPTEMBER 5 OF UNTREATED PLOTS

As shown by rows in the foreground, untreated plants were entirely dead at digging time. 1919 experiments.

was observed. (It should be remembered that the effect of nicotine sulphate sprayed on plants is not lasting.)

Hopperburn appeared in this plot a few days after the first spraying. On the Early Ohios, it spread slowly and surely, until the first week in August when all plants were practically dead. The treated rows were in as bad condition as an unsprayed row.

The Rural New Yorkers, although as heavily infested all summer as the other potatoes, remained fairly free of injury. By the middle of August, however, hopperburn began to spread to these plants and in a week about half of each plant was dead. An untreated row was slightly more affected than the others.

Kerosene Emulsion Does Not Control Hopperburn

One plot of Early Ohio and Green Mountain potatoes was sprayed three times with kerosene emulsion diluted to contain 10 per cent kerosene.

The infestation of adults was not noticeably reduced. Nymphs present at the time of spraying were readily killed, but great num-

bers continued to hatch and did not appear to be killed by any oil remaining on the leaves. There was no repellent effect observed upon adults or nymphs. The Early Ohios were practically dead by the last week in July. The Green Mountains were badly affected by the middle of August. The untreated rows of each variety were in slightly better condition than the treated rows.

Yields

The yields of the four treated plots and the untreated rows are summarized below. The exact yields per acre are not given on account of the difficulty in figuring acre yields from such small plots. The proportionate yields of treated and untreated rows, clearly shows that protective sprays have a decided value.

Bordeaux mixture plot—The treated rows of Rurals yielded twice as many potatoes as the untreated rows; the Green Mountains yielded practically twice as many in the treated rows. The ground in this plot was lacking in fertilizer.

Bordeaux-nicotine plot—The two rows of each variety in the treated plot yielded in proportion to the two rows in the untreated plot as follows:

Early Triumph—no marketable potatoes in either plot.

Early Ohio—twice as many as in the check.

Irish Cobbler—two and three-fourth times as many as in the check.

Green Mountain—two and one-third times as many as in the check.

Late Puritan—two and one-sixth times as many as in the check.

Rural New Yorker—one and fourth-fifth times as many as in the check.

The ground comprising these two adjacent plots had been well manured and was in good condition.

Nicotine sulphate plot—The treated rows of Early Ohio potatoes yielded one and one-half times as many tubers as the untreated rows; the treated rows of Rurals twice as many as the untreated rows. This plot has been manured from time to time.

Kerosene emulsion plot—The treated rows yielded one and one-fourth times as many Early Ohio potatoes as the untreated rows, and one and one-fourth times as many Green Mountains as

the untreated rows. The ground comprising this plot had not been fertilized for some time.

Conclusions—The treated rows gave much higher yields, ranging from one-fourth higher with Early Ohios and Green Mountains sprayed with kerosene emulsion, to two and three-fourth times as high with Irish Cobblers sprayed with bordeaux-nicotine.

Rural New Yorkers showed less difference in yield from three kinds of treatment than any other variety. They also were infested less by the leafhopper than any other kind. That it paid to spray them, however, is clear.

EXPERIMENTS IN 1920

Bordeaux Mixture Again Proves Effective

Bordeaux mixture, the most practical spray used in 1919, was given a severe trial in 1920 on a large plot of ground planted to five varieties of potatoes; Early Triumph, Early Ohio, Irish Cobbler, Green Mountain and Rural New Yorker. We wanted to see if this spray would again have the effectiveness in controlling the potato leafhopper and thereby largely preventing the appearance and spread of hopperburn. The plot was sprayed four times with bordeaux mixture. A good portion of each variety was left unsprayed as a check.

Early Triumph[7]—The infestation of adults and nymphs was generally light to moderate, at no time being heavy, although relatively more "hoppers" could be found here than on any other variety. On the check a heavy infestation occurred most of the summer. Hopperburn appeared the last of June, but due to the beneficial effect of bordeaux spread slowly although steadily until the vines died the last of August. The unsprayed vines were severely affected with the disease, dying early in August. (Fig. 17.)

Early Ohio and Irish Cobbler—The infestation of adults and nymphs on these two varieties was generally light all summer. During the latter part of the season it was often difficult to find any "hoppers" at all. The check plants were moderately infested early in July and became very heavily infested early in

[7]This variety was certified Wisconsin seed and did not die of hopperburn nearly as soon as did the plants from diseased vines used in 1919.

FIG. 17.—TRIUMPHS WITHSTAND LEAFHOPPER ATTACK WHEN SPRAYED WITH BORDEAUX.

Plants at right of stake sprayed four times and still green; plants at left of stake not sprayed and dead. 1920 experiments.

August. Hopperburn appeared on both varieties early in the season but was held in check by bordeaux up to August. From then on it spread gradually and by September was rather heavy. The vines were unhealthy looking but not dead. "Burn" on the check plants was heavy by the last of July and all vines of both varieties were practically dead by the middle of August.

Green Mountain and Rural New Yorker—Few leafhoppers, either adults or nymphs, were found all season on these varieties. Many were found on the check plants, the infestation becoming heavy before the end of the season. Hopperburn was not severe on the Green Mountains and on September 14 the vines were green and fairly healthy. Little disease occurred on the Rurals, the vines remaining green and healthy up to the middle of Sep-

tember. The beneficial effect of bordeaux was very noticeable. On the check plants, however, hopperburn was severe especially during August. The Green Mountain vines were dead early in September. The Rurals were severely affected but not dead.

It was repeatedly observed on all the varieties that the infestation of leafhoppers decreased greatly after an application of bordeaux and a week or two elapsed before an increase was again noticed.

The yield of the five varieties was small on account of a dry season and because they were planted on a light, sandy slope, but the treated portion of the plot yielded more tubers for each variety than did the untreated portion.

Recommendations for Control

Spraying appears to be the only practical method of controlling the potato leafhopper and thus preventing the appearance or spread of hopperburn.

Bordeaux mixture, 4-4-50 is effective in repelling the insect and in checking the "burn." This spray alone should suffice.

Spray the *underside* of the leaves thoroughly. Use a good sprayer in first class condition and keep the pressure up to at least 150 pounds. Use nozzles throwing a fine mist. Spray each side of each row. Spray three times at least. If you have sprayed three times, spray once more if leafhoppers or hopperburn persist.

Great difference in the severity of hopperburn on different varieties of potatoes has been shown by the foregoing experiments. Of the varieties used, Early Triumphs were always affected worst; Rural New Yorkers always least. Therefore, Triumph potatoes should be sprayed early, often, and with great care in order to preserve the foliage until a crop of tubers has had time to develop. Early potatoes generally should be more closely watched than late ones. Rurals could better withstand a delay in spraying or lack of an extra spraying than any other variety used in these experiments.

Use More Bordeaux

It has been used with success for many years in the control of early and late blight and of the potato flea beetle.

It is an effective control of potato leafhopper and hopperburn.

An arsenical added to bordeaux mixture makes a spray which will assure a crop in spite of nearly all insects and diseases which attack the foliage.

It is a universal and vital treatment for potatoes, and should be applied often, properly, and thoroughly.

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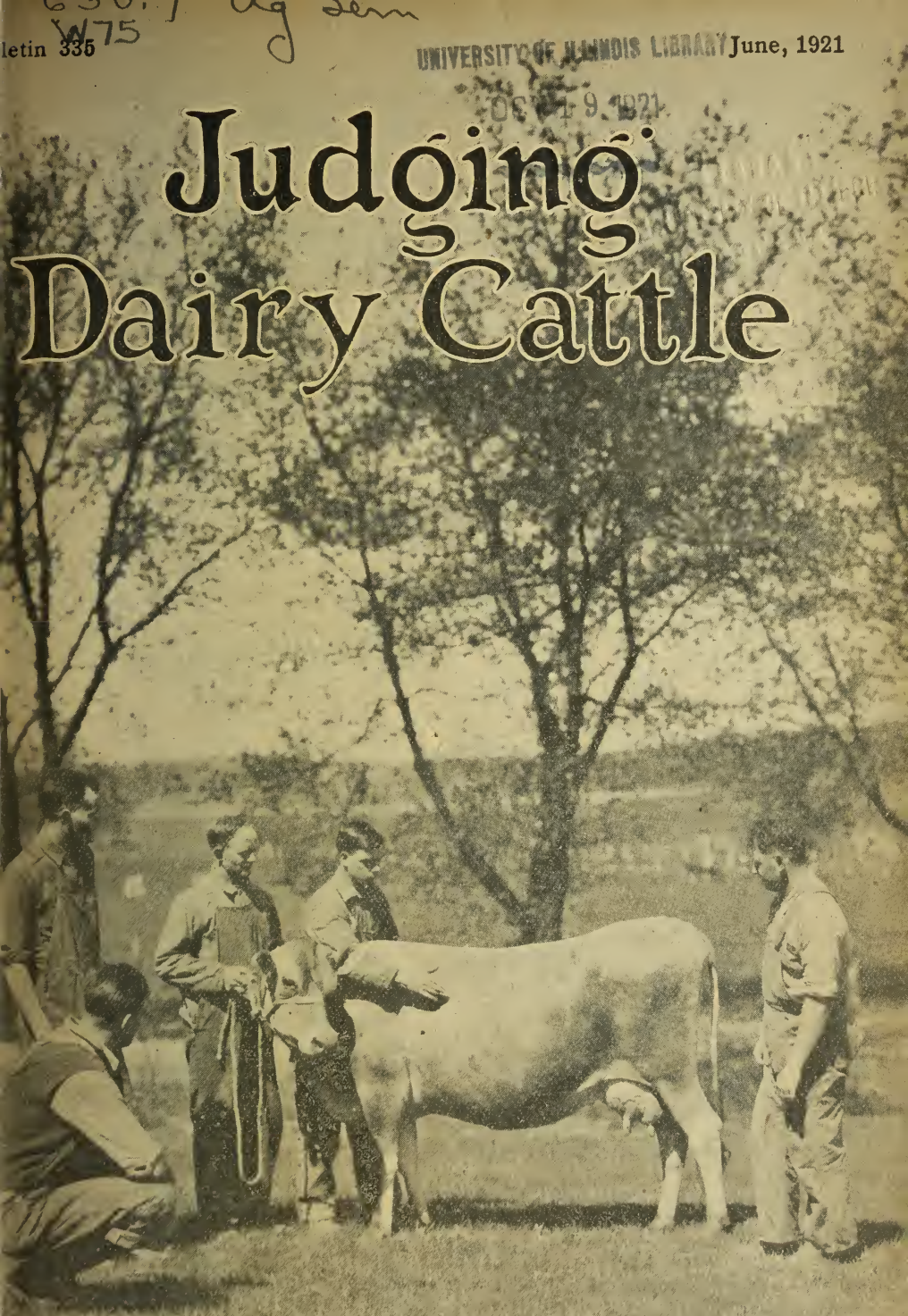
Judging Dairy Cattle



AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF WISCONSIN
MADISON

DIGEST

The most successful dairyman is a good judge of dairy cattle. The development of higher standards relating to the maintenance of dairy herds and the production of most satisfactory milk make it necessary to improve the herd if dairying is to be profitable. Quality and productiveness of cows are more important than a larger number of cows. Judging exercises are of great value in bringing about this end.
Pages 3-6

Dairy cows of improved type and breeding are milk-making machines. They have size and capacity for feed consumption, constitution and good health, dairy disposition and good udders which are primary essentials. They furthermore produce most valuable offspring.
Pages 7-8

Feed capacity and dairy temperament are indicated by triple wedge-like forms of the body. One is on the side, one on the back, and the other in the shoulders. The base of these wedges or triangles indicates feed capacity, the sharp point dairy temperament. Pages 9-12

Constitution and well-developed milk organs are highly essential. No cow is ever perfect. Udders that are well developed and nicely balanced, together with general style and quality, add much to the value of good producing cows. Pages 13-19

The Babcock tester and the milk scale must be relied upon for final judgment on a cow's ability to produce milk and butter fat. Dairymen could gain millions of dollars' worth of feed by weighing and testing the milk of individual cows. Page 20

Pedigrees are of value in judging the future returns and excellence of the herd. A pedigree shows the ancestors of a given animal and its value lies in the fundamental law that "like tends to produce like". It pays to have a herd comprised of one family of high-producing cows.
Pages 20-24

Most careful judgment should be exercised in selecting the dairy bull. When well selected, "the sire is more than half the herd". Proven, "bred-for-production" sires should be preserved and used to the fullest extent. Pages 24-26

The best judges of dairy cattle usually own or manage a good dairy herd and make a careful study of judging. A score card or scale of points, the object of which is to train the mind to notice the various parts of the animal, may be used to good advantage in acquiring the art of judging. One should never miss an opportunity to take part in judging exercises and contests. Community judging contests develop cattle judges and improve dairy herds. Pages 27-31

Wisconsin has many herds of most excellent dairy cattle. They have been developed by men whose judgment has been based on production and showyard standards of excellence embodied in production records, representative animals, and a scale of points for the breed.
Pages 32-44

Judging Dairy Cattle

George C. Humphrey

The most successful dairymen are usually good judges of dairy cattle. The ability to select profitable from unprofitable cows has always been a strong factor in successful dairying; and in the future, even more than in the past, it will be highly important for all dairymen to acquire this ability.

The permanency of dairy farming is assured by the growing appreciation and increased consumption of milk and milk products. Incident to the growth of the dairy industry, there are higher standards developing relative to conditions under which

A Good Judge of Dairy Cattle

Makes fewer mistakes in buying cattle.
Gets better prices for his surplus stock.
Selects and builds up a herd of cows of uniform size, breed and quality.
Receives a higher and more uniform production of milk and butter fat.
Makes greater returns over and above the cost of feed and care.
Uses better sires and secures better calves.
Has better success in feeding and showing cattle at fairs and expositions.
Has greater satisfaction and pleasure in owning a dairy herd.

milk is produced, that make it necessary for the farmer to maintain only the best class of cows. The cost of feed and labor, and the maintenance of sanitary and clean equipment to insure healthy cows and a satisfactory product, naturally make the demand for bred-for-milk-and-butter-fat cattle insistent. It is becoming more and more important to know all the facts that enable one to select cows which will qualify for large and profitable production of milk and butterfat.

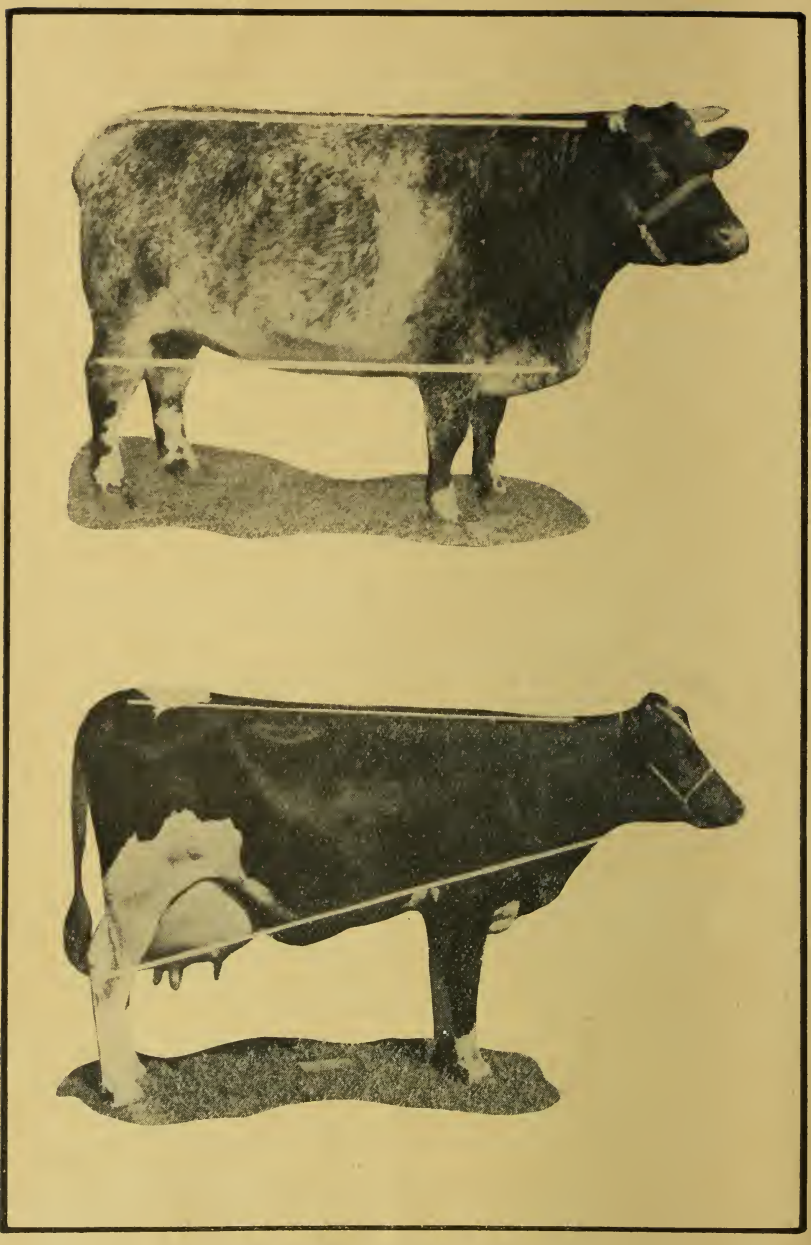


FIG. 1—THE DIFFERENCE BETWEEN BEEF AND DAIRY TYPES

The beef animal has straight top and bottom lines, while the dairy cow is wedge shaped.

FIG. 2—BEEF ANIMALS BLOCKY, DAIRY CATTLE ANGULAR

Fullness of the fore and hind quarters are typical of the beef animals. A comparatively long head, sharp brisket, and a pronounced udder development characterize the dairy cow.

EDUCATIONAL VALUE OF JUDGING EXERCISES

Judging exercises and judging contests are of distinct educational value and have become popular in the programs of high schools, secondary schools, community and breed association meetings, and boys' and girls' club meetings. Judging dairy cattle and other livestock develops observation and judgment on the part of those who participate. Contests or judging exercises can be recommended for every school and community of the state. Such exercises stimulate a greater interest in livestock and promote better standards for rural livestock production. Wisconsin is destined because of its present advanced stage in dairying, its climate, its nearness to good markets, and the training of its people, to occupy a highly important place in the dairy industry of America. It is more important to improve the quality and productiveness of the cows than to increase the number and the size of the herds to meet the demands for dairy cattle and dairy products. Careful judgment in the selection, breeding and development of individual herds depends on having a clear knowledge of the dairy cow and her requirements.

WHAT IS A GOOD DAIRY COW?

Cows which are heavy producers usually have certain well-defined characteristics common to one of the recognized dairy breeds. The National Dairy Show Association of this country recognizes Ayrshires, Brown Swiss, Guernseys, Holsteins and Jerseys as the leading dairy breeds. Purebred animals possess 100 per cent of the blood of their respective breeds. Grade animals have a predominance of the blood of a given breed, but less than 100 per cent. Grade cows are usually by purebred sires and out of native or grade cows. The breeding or ancestry of a cow largely determines her characteristics, the use she makes of her feed, and the characteristics of her calves. Dairy breeding insures in a great measure against disappointment when one buys or raises a cow for milk production. Furthermore it gives her power to reproduce herself in offspring that tend to correspond to her in type and excellence.

Cows which possess certain so-called "dairy characteristics" are, as a rule, more economical producers of milk and butter fat than those which lack these features. A ready acquaintance with these,

as well as with the line of breeding represented, will aid the dairyman in selecting profit-producing cows. Even the most expert judges of dairy cattle are unable, of course, by relying solely upon the appearance and a study of family records, to foretell a cow's ability to produce milk and butter fat. That, in the end, is told only by the use of the milk scale and the Babcock tester.

The dairy cow is a most wonderful living machine; but to be worthy of the name, she should have in addition to dairy breeding

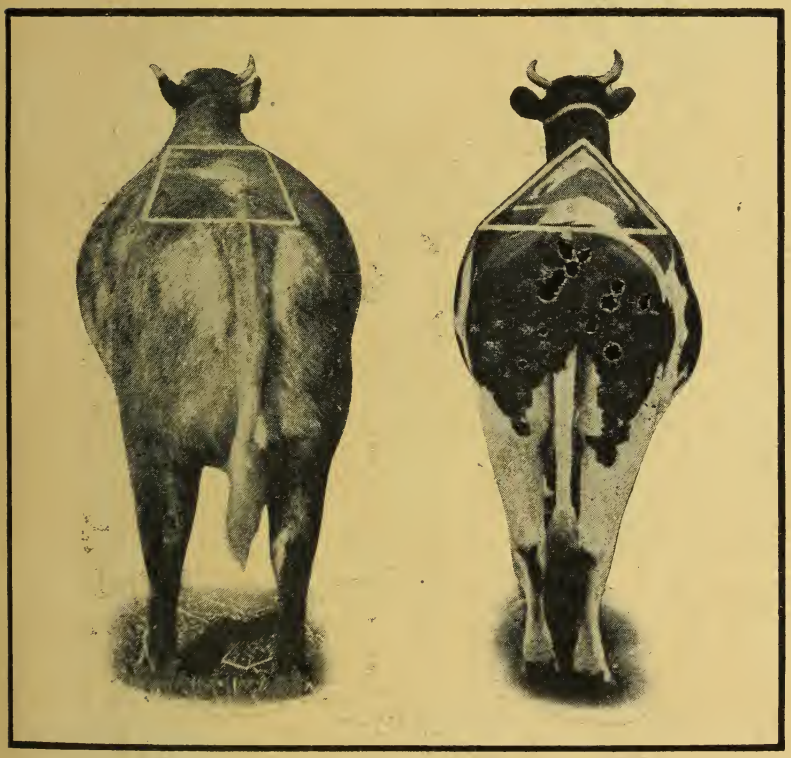


FIG. 3.—BEEF AND DAIRY TOP LINES

Beef animals utilize feed for developing a broad and thickly fleshed back. A triangular shaped back indicates dairy type and milk production.

and good size for her breed certain other characteristics. They are: feed capacity, dairy temperament, good constitution and health, and well-developed milk organs—all of which are essential to a large and profitable production of milk and butter fat. A cow usually fails in the production of milk and in commanding the

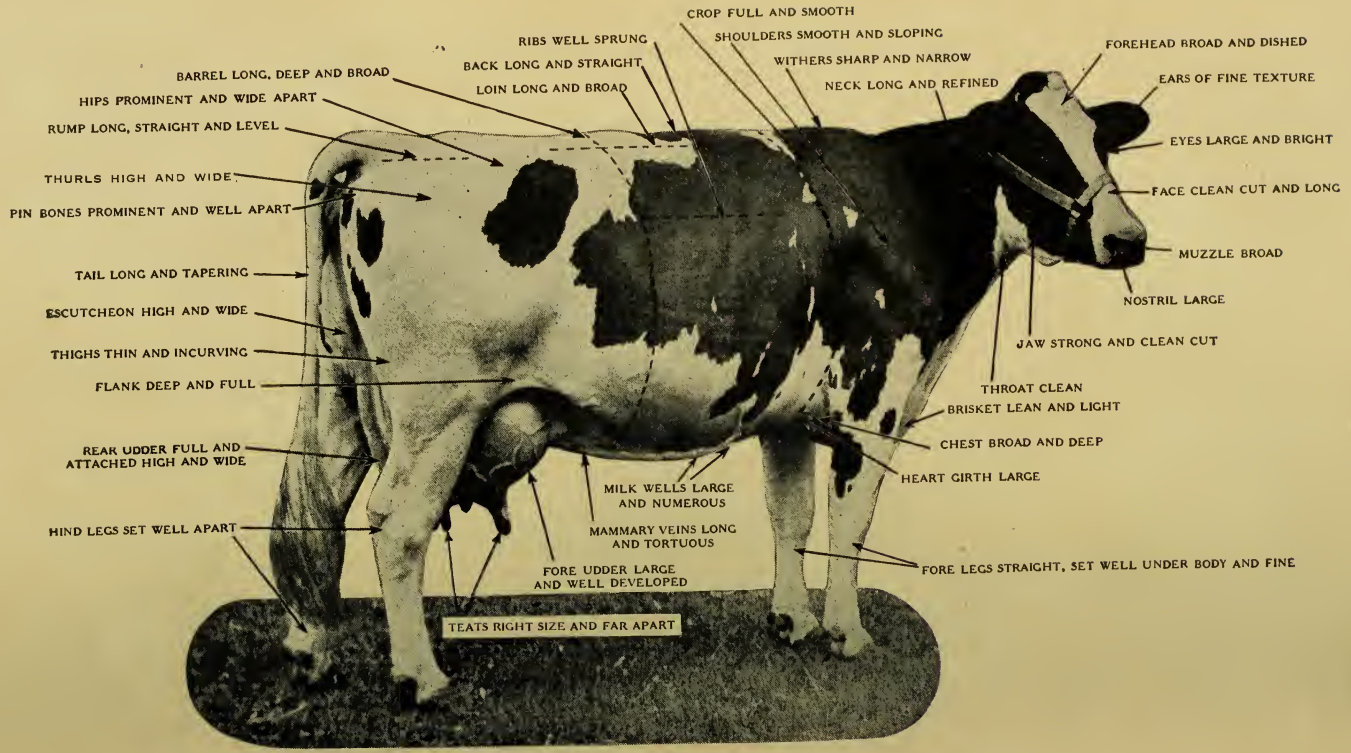


FIG. 4.—THE PARTS OF A DAIRY COW

A dairy cow should have large capacity for feed, a dairy temperament, well developed milk organs, fine quality, perfect health, and be capable of a large production of milk and butter fat. Duchess Skylark Ormsby, a former champion cow for yearly butter fat production, record 27,761.7 pounds milk, 1,205.09 pounds butter fat, shows excellence in all parts.

highest price, to the extent that she is lacking in one or more of these essentials. (Each part of the body shown in Figure 4 bears some relationship to one or more of them.)

Because symmetry and beauty please the eye and may have a definite value in determining the animal's ability to qualify as a profitable cow, she should also have style and quality which are indicated by a straight, level back and rump; clean-cut face and neck; straight, well-placed legs; symmetrical bones of good quality, fine hair, and mellow hide. Where one is able to consider all parts of the body and judge the essential features, he is not likely to err seriously in his judgment.

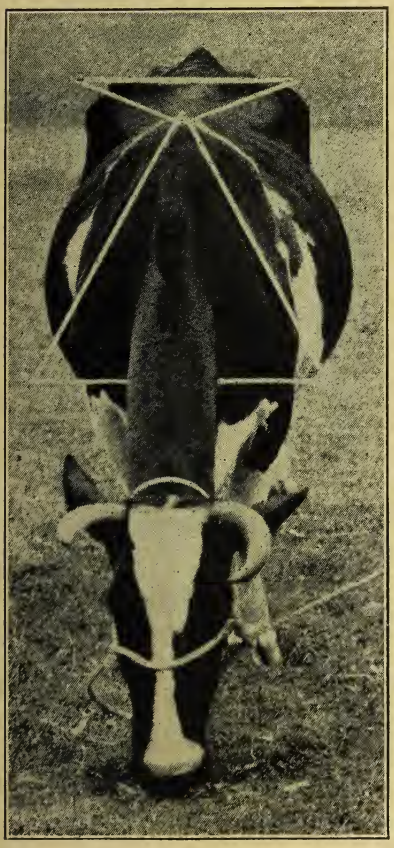


FIG. 5—LOOK FOR THE WEDGES

The body should be wedge shaped when viewed from the front and top of the withers, wider at the hip bones and at the floor of the chest than at the point of the withers.

FEED CAPACITY

A large body, more especially the barrel, in proportion to the size of the animal indicates feed capacity. The body of the dairy cow should be wedge-shaped as viewed from either the front, the side, or the top of the withers. It should be wider at the hip points and pin bones than at the withers. The floor of the chest between the fore legs should also be wider than the top of the withers. Again, the body should be deeper from the hip points to the bottom of the udder than it is at the forequarters.

These characteristics of the body have led to the term "triple wedge-shape conformation." In considering the digestive capacity of the cow, it should be remembered that the base ends of the three wedges rather than the sharp ends indicate feed capacity.

Large digestive capacity is indicated by ribs well-sprung and far apart, an open chine, a back wide over the loins, wide-apart hips, and full and deep rear flanks resulting in a large body or so-called barrel. A wide forehead, a comparatively long face, broad muzzle, good-sized mouth and strong, sinewy jaws, are also considered indications of a large digestive capacity.

The tail is often measured in judging a cow; and to meet the standard requirements it should reach to, or below, the hocks and carry a good switch. This makes it most useful in brushing flies which is its chief purpose. Except that the loose joints of the tail indicate an open condition of the vertebrae of the back—which is

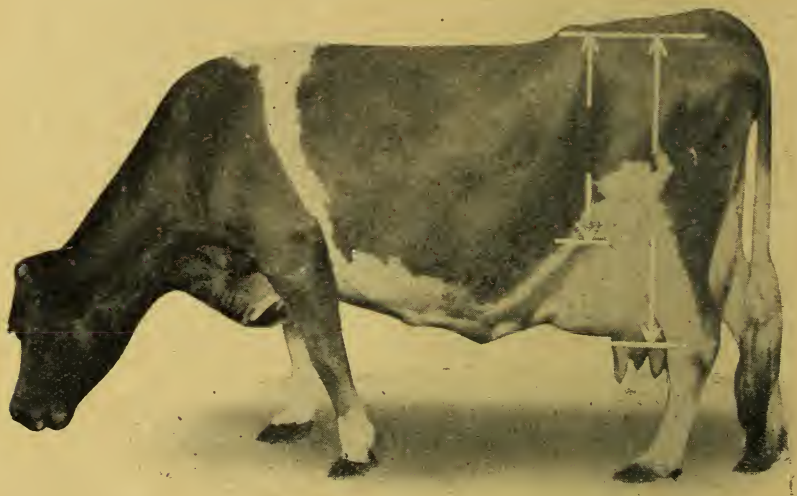


FIG. 6.—GREAT DIGESTIVE CAPACITY IS ESSENTIAL.

Fullness of flanks and good depth from the hips to the lower line of the rear flank and of the udder, together with well sprung ribs far apart, indicate a large digestive capacity.

desirable in the dairy cow, and may indicate length of body and thus greater capacity for feed—it is difficult to understand how a long tail would have any relation to milk production.

DAIRY TEMPERAMENT

The dairy temperament or dairy disposition of a cow indicates her ability to convert feed into milk rather than into flesh. The dairy breeds have acquired this ability through the process of selection and breeding for milk and butterfat production. It varies

in strength even among purebred dairy animals and, therefore, needs to be carefully considered in judging. A cow that is a large and economical producer of milk and butterfat is almost certain to have a highly developed dairy temperament.

Cows excelling in dairy temperament show the following characteristics:

Head and face—clean-cut in outline and indicative of fine quality. **Eyes**—prominent, bright and active. **Neck**—fine, clean-cut, neatly joined to the head, not too full at the throat and comparatively long and thin. **Shoulders**—oblique, comparatively bare of flesh and sharp at the withers. **Backbone, hips and pin bones**—prominent and sharp. **Ribs**—more or

FIG. 7.—A SHALLOW BODY LACKS CAPACITY

A narrow head, small eyes, nostrils, and mouth, usually accompany a narrow shallow body. A cow with these characteristics proves a disappointment as a milk producer.

less prominent and open. **Thighs**—thin and incurving, sometimes termed "cat hams." **Bones**—in all parts of the body indicating quality rather than coarseness.

SHARP WEDGES INDICATE TEMPERAMENT

The lean, muscular tissue on the outside and underneath the shoulder blades and along the back, accounts for the compara-

tively sharp condition of the withers. The wedge-shaped conformation shown in Figure 5 is due to the absence of flesh about the neck and the forequarters. It may be said, therefore, that the sharp end of the triple wedge-shaped conformation is indicative of dairy temperament.

In judging quality and condition of the muscular tissue of the body, an allowance for the size, age and stage of lactation of the animal should be made. It should also be borne in mind that the bones and muscular tissues in a large cow are naturally heavier than in a smaller or younger animal. Then, too, there is not the natural refinement and spareness of form in the larger breeds that there is in the smaller ones. Marked coarseness, however, in any animal is undesirable. It is usually accompanied by a sluggish disposition that prevents the dairy cow from "performing at the pail"

FIG. 8.—A COW WITH MARKED DAIRY TEMPERAMENT

Clean cut features about the head and face, the fine clean neck, the prominence and sharpness of the back bone, hip points and pin bones, the thin, incurving thighs and the clean, fine shanks in this cow are indications of extreme dairy temperament.

satisfactorily. Young heifers with their first calves usually carry more flesh than cows of mature form. All cows that are properly fed usually show more flesh development toward the close of lactation and prior to freshening than they do when four or five months advanced in lactation. This should be considered in judging dairy temperament.

CONSTITUTION AND VIGOR

A cow, to be most profitable, should possess strength, vigor, and health to insure her ability to work a reasonable number of years at producing milk and offspring. The period of usefulness of a cow depends upon a rational system of feeding and management, as well as upon constitutional strength. There are great differences, however, in what appears to be the natural strength and endurance of cows. Johanna Clothilde 4th, the foundation of the University Johanna family of cows, lived to her fifteenth year. Her twelve years' work in the University herd resulted in five daughters and six sons, and an average annual production of 12,616.43 pounds of milk and 452.20 pounds of butterfat. This is one example of how a good dairy cow should be able to maintain a profitable production until ten or more years of age. As a matter of fact, however, many cows do not prove profitable to this age.

Size corresponding to that for the breed, without coarseness, and a healthy circulation of blood to all parts of the body, combine to indicate health and vigor. The dairy cow yields greatest profits and performs her work easily only when all parts of the body perform their respective functions and there is capacity for feed consumption and milk production. When the cow is sick or naturally dull and sluggish, all the glands of the body are inactive. The result is a dry, harsh condition of the skin, a staring coat and a low production of milk. The blood circulatory system includes the heart, lungs, arteries and veins. These organs respectively force, purify, and carry blood to and from all parts of the body.

When the feed which the cow eats is digested and assimilated the blood carries it to the various parts of her system including the udder. This is abundantly supplied with blood vessels, and in producing a full flow of milk converts approximately 30 per cent of the digestible nutrients of the ration into milk. Nearly 25 per cent more of the digestible nutrients of the ration go to produce the energy required to make the milk. The balance of 45 per cent of the nutrients serve for body maintenance. A large amount of blood circulating to the udder is especially essential to milk production. This is judged largely by the veins appearing on the under side of the body and quite frequently on the outside of the udder. The oily condition of the skin and the oily

secretions noted in the ears and at the end of the tail indicate a strong circulation of blood to all parts of the body, and the activity of all healthy glands including those of the udder. Large, open nostrils, providing ample air passages to the lungs for purification of the blood, are important. A narrow head, small mouth, contracted listless eyes, and a narrow body with a heart girth indicating lack of fullness back of the shoulders and especially in the region of the fore flanks, indicate poor constitution and vigor.

WELL-DEVELOPED MILK ORGANS HIGHLY ESSENTIAL

The udder is the milk secreting organ, and its proper development is therefore essential. Associated with the udder are the

FIG. 9.—THE LOCATION OF THE MILK WELLS

Several milk wells of good size through which the mammary veins pass into the body are the best indications of the amount of blood that circulates through the udder and supplies the milk secreting glands.

mammary veins, frequently called "milk veins," on the under side of the body extending forward and disappearing through openings termed "milk wells." These veins do not carry milk but carry blood away from the udder. They are usually regarded as part of the milk organs and are considered with the udder in judging its quality, form and capacity. Blood sometimes becomes gorged in the veins as a result of too small milk wells, a point that should be considered in judging the size of the veins. Cows, even of

large digestive capacity and of pure dairy breeding, fail to make satisfactory production when they have poorly developed milk organs.

The udder consists of two large glands, more or less distinctly divided to correspond with each of the four teats. The duct of each teat enters a small cavity termed the "milk reservoir." The milk reservoir of each quarter is more or less surrounded by lobes of glands held closely in position by connecting tissue. These lobes resemble thick bunches of grapes. Each lobe has several divisions called lobules corresponding to the grapes. The lobules are made of small divisions called "alveoli," which correspond to the seeds of the grapes. These alveoli are again made up of small cells surrounded by fine network of blood vessels and nerves. Milk is secreted by these cells; and it is believed that the more tortuous

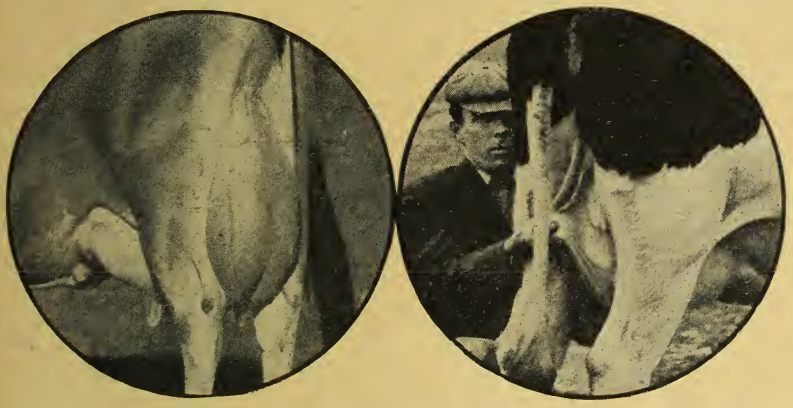


FIG. 10.—TYPES OF GOOD UDDERS

The udders should be large, well proportioned, balanced, extended far forward, and high up between the thighs. (See udder on left.) It should be of fine texture, pliable, and the skin should stretch readily when the udder has been milked out. (See udder on right.)

and branching the milk veins are and the more extensions they have that pass into numerous wells, the greater the capacity of the cells of the udder will be for secreting milk.

The best cows of all breeds have comparatively large udders with equally developed quarters extending well forward underneath the body and a good distance up behind and between the thighs. Swinging or pendulous udders result from poor attachment. Irregularity in the development of the quarters is a criticism to be offered on many udders. The first consideration, however, should be size and quality. The udder tissues should be fine and plastic rather than fatty or coarse and hard.

FIG. 11.—PROMINENT UDDER VEINS

A good circulation of blood through the udder is indicated by the prominent udder veins. Teats of good size and well placed make hand and machine milking easier.

the milk organs and indicative of their capacity for producing milk. If this is true, the escutcheon should be given as much importance as the milk veins. Guenon also regarded the peculiar condition of spots of hair noted at the back side of the udder of some cows and termed "thigh ovals" as an important point to consider in connection with the escutcheon. A lack of positive knowledge, however, of the relation of these features to milk production prevents giving them as much consideration as is given to the milk veins. A wide escutcheon that extends high at the rear of the quarters is considered most desirable, and usually is allowed one or two points on the score card for dairy breeds.

This condition, combined with a good system of veins underneath the body and well-developed on the udder, constitutes well-developed milk organs.

The escutcheon, which is outlined by a mark made by the difference in direction in which the hair runs at the rear of the thighs above the udder, was thought by Guenon, a French student of the dairy cow, to be associated with the arteries that carry blood to the udder. The escutcheon, therefore, would be associated with

FIG. 12.—ESCUTCHEON AND OVALS

The escutcheon is outlined by a line formed by the difference in the direction of which the hair lies above the udder. The thigh ovals when found on the rear of each hind quarter of the udder are regarded as indications of a large milk flow.

STYLE AND QUALITY

No cow ever existed that could be called perfect in all respects when scored by a critical judge. Every animal will be more or less deficient in regard to form and features that are considered in judging her value. Style relates to symmetry of form, breed characteristics and the general beauty and attractiveness of the cow. Good proportions and a clean-cut appearance of the head, neck, shoulders, body, hind quarters, udder and legs, have much to do in giving a cow a well-balanced and neat appearance. A straight top line, including the back and rump; a neck not set too low and free from throatiness and unnecessary dewlap; shoulders that blend nicely with the body and are free from coarseness and undue prominence over the tops; and fineness of bones at the hip points and about the tail and legs, are all marks of good style. Too much refinement that would tend to make the animal appear delicate and inefficient would naturally detract from proper style.

Much of the style of an animal depends upon good quality of the texture of various parts of the body. Fineness and smoothness of the bone and hair, the pliable oily texture of the hide, waxy appearance of the horns and hoof, brightness and alertness of the eye, and a general healthy appearance of the animal are marks of good quality.

Deficiencies which detract from style and quality are:

Head lacking width and dish of forehead; too long or too short, narrow at the muzzle or coarse in appearance.

Horns coarse and poorly set and turned.

Body too short or lacking in depth with ribs too close, too short, or too straight.

Back not level.

Hind quarters short, narrow or drooping with thighs too thickly fleshed.

Udder unbalanced and irregular in shape, with teats too short, irregular in size, or improperly placed.

Legs crooked, out of proportion in size of bone, apparently too short or too long, and set too close or too far apart.

A tail set too far forward, too heavy in bone and too short.

FIG. 13.—TWO TYPES OF [illegible] RUMPS
Rumps that droop and are low at the pin bones detract from the beauty of the cow and are usually accompanied by udders which tilt forward.

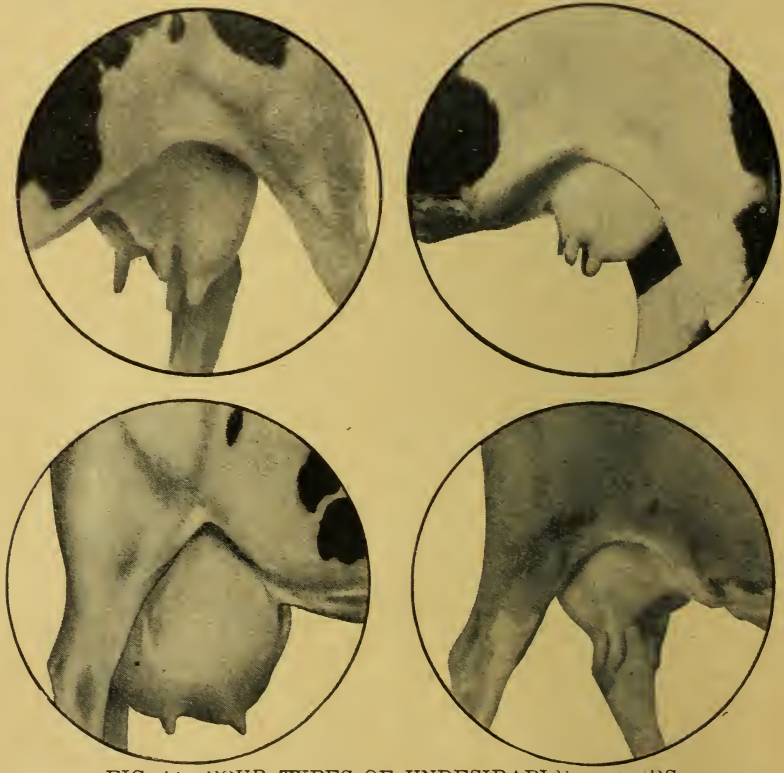


FIG. 14—FOUR TYPES OF UNDESIRABLE UDDERS
Udders deficient in the fore quarters, irregular in the size of quarters, pendulous in form or funnel shaped make milking hard and reduce the capacity for milk production.

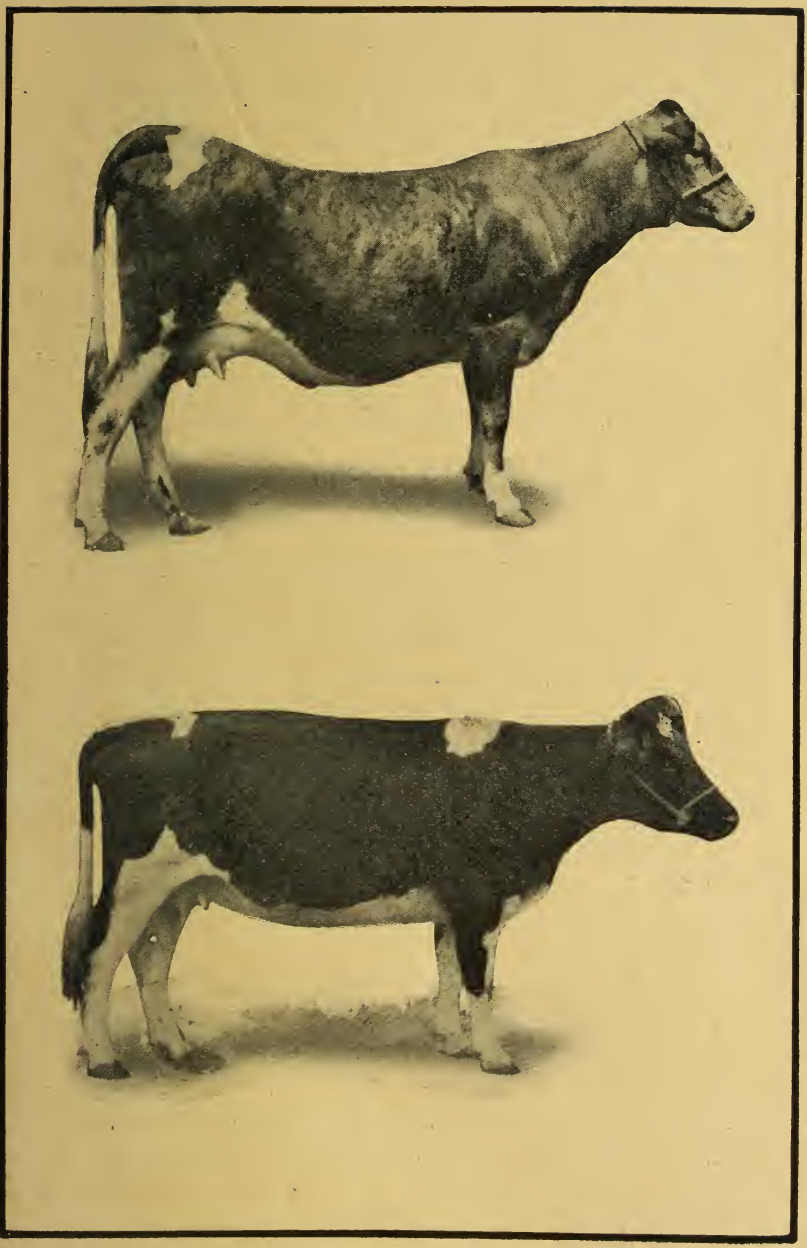


FIG. 15.—INFERIOR TOP LINES

A straight, strong back is most desirable. Backs which are not straight detract from the general appearance of the cow and may indicate weakness.

JUDGING BY RECORDS OF PRODUCTION

The cow is very much like a race horse when it comes to judging her ability to perform. Both must be judged by their appearance together with their record of performance. The milk scale and the Babcock tester, assisted by judgment of the eye, are the best means of selection in building up a profitable dairy herd. Persistently following this means of judging will lead to the establishment of a herd which is both pleasing to the eye and capable of a large and profitable production of milk and butterfat. Every dairyman can afford to weigh the milk from each cow at each milking and have a sample of the milk of each cow tested once a month. Results accurate enough for all practical purposes may thus be secured.

SCALE AND TESTER WOULD INCREASE PROFITS

Feed worth millions of dollars is now being eaten by cows that do not pay their cost of keep. This feed would be saved annually or converted into milk, and the value of dairy products of the state would be greatly increased if the scale and tester means of judging were employed on every dairy farm.

The Advanced Registry system, maintained by dairy cattle associations, records the milk and butterfat production of cows officially tested, and gives valuable aid in judging many purebred dairy animals on the basis of their ability to perform. Cow-testing associations, directed by competent supervisors, are highly valuable in helping dairymen to judge the production ability of their cows.

THE PEDIGREE AS A BASIS FOR JUDGING

In buying dairy cattle and in selecting animals for breeding and milk production, the future returns and excellence of the herd should be considered. Such judgment must be based on a knowledge of the family or group of ancestors from which the animals descend. This frequently can only be determined by pedigrees.

A pedigree is a statement showing the ancestors of a given animal for two or more generations. Its value as the basis for judging lies in the fundamental law that "like tends to produce like." Where the ancestors of a given animal or group of animals are uniformly good, it is reasonably sure that individual or herd ex-

cellence and profitable returns for the future will be sustained. Dairymen will find it profitable to take pedigrees into consideration, together with individuality and performance in their efforts to make herd improvement.

WHAT CONSTITUTES A GOOD PEDIGREE

Excellent and uniform character of ancestors, more especially the immediate ones.

The absence of inferior or mediocre ancestors.

Lines of ancestry showing meritorious families of the breed.

Accompanying statements of facts regarding records of performance, show yard winnings, direct offspring of meritorious character, and bona fide sale values.

PEDIGREES MUST BE TRUE

The writer of a pedigree should be a responsible person and there should be every reason to believe that all statements are authentic. The so-called "padded pedigree," where statements in support of the ancestors of a given animal are far-fetched and only distantly applicable, is of little value to a judge and frequently misleading to the novice and to the public. The two pedigrees presented illustrate the contrast between a good and a misleading pedigree.

GOOD PEDIGREE

Sir Pietertje Ormsby Mercedes 37th, 110160.
Born Dec. 27, 1912.
Sire of: 18 A. R. O. daughters, 2 above 30 lbs., 10 others above 20 lbs.
Ponderosa Grace Pietertje Mercedes 3 yrs. Butter in 365 days, 1072.60 lbs., milk 23,360.00 lbs.
Greatest proven son of Sir Pietertje Ormsby Mercedes.

Sir Pietertje Ormsby Mercedes, 44931.
Sire of: 71 A. R. O. daughters, 2 with over 40 lbs; 11 others above 30 lbs., 35 others above 20 lbs.
12 above 1000 lbs. butter, semi-official in 365 days, 1 at 4 yrs. 1389.45 lbs., 1 at 4 yrs. 1323.36 lbs., 2 others above 1200.00 lbs.

Spring Brook Bess Burke 2d, 131387.
Butter 365 days, 1290.94 lbs. milk 24,918.10 lbs., butter 7 days 38.231 lbs., milk 792.301 lbs.
2 other semi-official records above 1000 lbs. of butter and 21,000 lbs. of milk.
Has 2 A. R. O. daughters, 1 with 40.74 lbs. in 7 days, 1043.65 lbs. in 365 days.

Jack Mercedes, 35077.
6 A. R. O. daughters, 2 with 22 and 30.44 lbs.
2 A. R. O. sons.

Pietertje Maid Ormsby, 78051.
Butter 7 days, 35.56 lbs., milk 535.40 lbs., butter 30 days, 145.66 lbs., butter 365 days, 759.13 lbs., milk 16,531.80 lbs.
2 A. R. O. daughters, 1 with 30.75 in 7 days, 1255.62 in 365 days, 3 A. R. O. sons.

Sir Johanna Canary DeKol, 44034.
18 A. R. O. daughters, 4 with over 30 lbs., 6 others with over 20 lbs. 2 A. R. O. sons.

Spring Brook Bess Burke, 98734.
Butter 365 days 1094.16 lbs., milk 25,227.10 lbs., Butter 7 days 34.81 lbs., milk 630.80 lbs.
Average for 3 A. R. O. records 31.95 lbs., 3 yearly records 839.75 lbs.

MISLEADING PEDIGREE

Colantha Oakland DeKol Clyde H. B., 149311.
Wt. 2000, born April 18, 1914.

A son of Dutchland Colantha Belle Boy and a well-bred dam.

His sire combines in the closest degree the blood of the two great century sires Colantha Johanna Lad and Hengerveld DeKol, who together have twenty-two 30-lb. daughters and fifty-six 30 to 37-lb. grand-daughters.

Dutchland Colantha Belle Boy, 70156

Rik Friesland Queen 4Y.	28.57
Junette Careme Johanna 2d 3½Y.	28.20
Abbekerk Lady Colantha 3Y.	27.24
Little Goldie of Wayside 3Y.	24.78

Two sons with A. R. O. daughters.

Records of his dam and sire's dam:

	Ave.
Butter 7 days	31.55
Half-brother to sire of Lorna D. Col.	35.00
Lakeview Dutch. Artis 3½ Y.	34.66
Col. Gladi Parana	31.72
Princess Aag. Inka 3½ Y.	31.68
Jenny Linn Col. 4Y.	30.95
Butter 30 days	122.51

Ida Oakland DeKol Clyde, 202462.

Her sire is a half-brother to the dam of:

Urma Burke 6 Y.	35.21
Ave. per cent Fat 5.26, Milk	535.20
Butter 7 days 5 Y.	30.24
Ave. per cent Fat 5.46, Milk	443.10
Butter 7 days 4 Y.	26.65
Butter 7 days 3 Y.	24.90
Grace Segis DeKol Boon 4½ Y.	31.65
Urmagrace	31.26
Butter 30 days	125.95
and to the sire of Lotta Clyde 7 D. 7 Y.	31.33

How to Judge a Pedigree

Considerable knowledge of individual animals and of families representing the respective breeds is necessary to enable one to judge on the basis of pedigree. The pedigree is of most value only in the hands of those familiar with the character and performance of the animals named. The experiences and knowledge of reliable men who have successfully engaged in the breeding and building of herds is invaluable and should always be sought by younger men, who are naturally beginners. Concentration of interest on a given breed, and better still on a few of the families of a breed, is highly essential to success in acquiring a working knowledge of pedigrees. After one has had the experience of breeding several generations of animals in a given herd and has taken advantage of the opportunity to study and make many observations, it is natural to rely on the pedigree as one of the important means of judging. The following suggestions are offered on how to acquire a knowledge of pedigrees.

Study breed literature and learn to know the leading families and the most prominent individual animals of a breed.

Become acquainted with men most prominent in promoting the affairs of a breed.

Visit fellow breeders, sales, and shows.

Keep posted on facts relative to your herd development and improvement.

In herd development, have animals of one family predominate with which you are thoroughly familiar.

JUDGING THE DAIRY BULL

The dairy bull, like the dairy cow, offers great opportunity for the exercise of judgment. A knowledge and consideration of the parts shown in Figure 16 are necessary for judging and valuing the bull. As an individual, the dairy bull should be typical of his breed and show feed capacity, dairy temperament, constitution and vigor, style and quality, similar to the cow. A masculine character indicated by greater size for his age, greater strength and vigor, a stronger neck well-crested at full age, heavier and more prominent shoulders and forequarters, together with only rudimentary teats and a fairly discernible mammary vein system, are the characteristic differences one would note in judging the

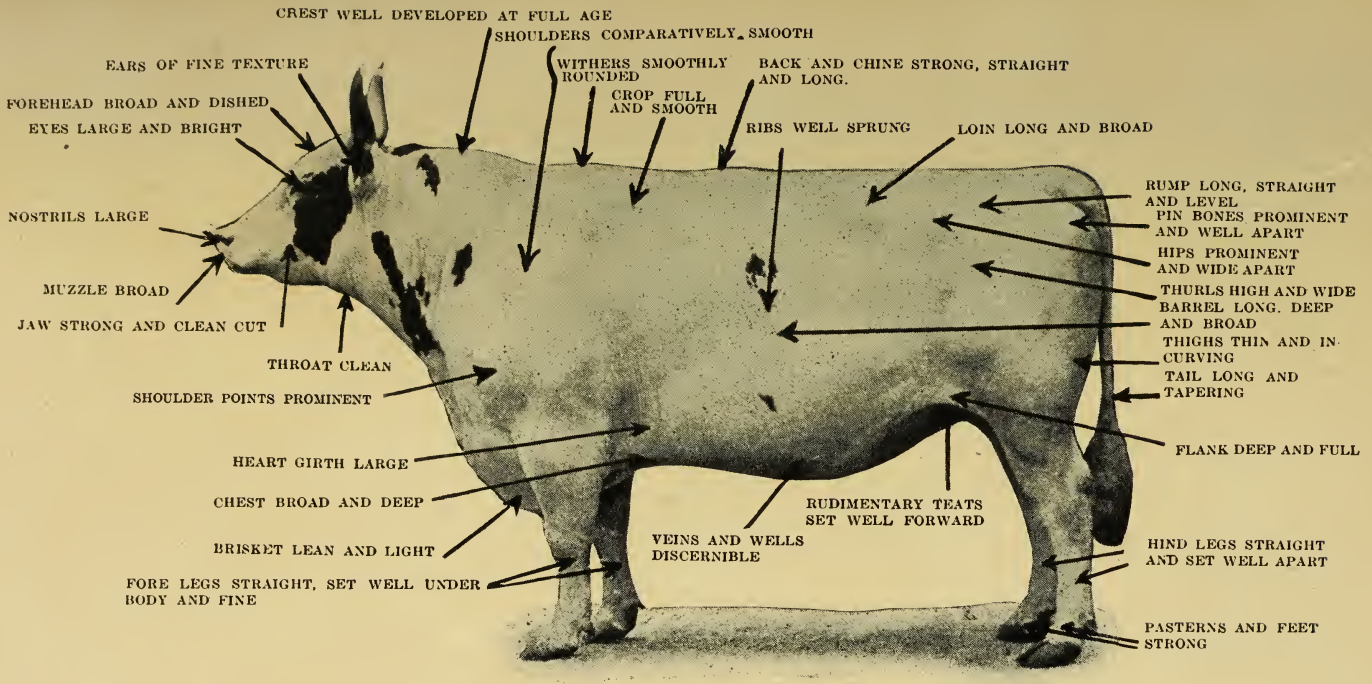


FIG. 16.—A DAIRY BULL SHOULD BE TYPICAL OF HIS BREED

He should have good size for his age and show feed capacity, dairy temperament, quality, masculinity, vigor and lines indicating style. His prepotency and milk production ability must be shown in his daughters.

individuality of a bull and that of a cow. Particular attention should be given to a well balanced conformation and blending of parts, a soft pliable hide with oily secretions and a fine, velvet-like coat of hair. Considering these together with the parts defined in Figure 16 gives a basis for judging a bull's individuality.

JUDGING THE BULL AS A SIRE

The dairy sire is of more importance than any other animal in the herd because of the great influence he exerts on the breeding and building of the herd. There is much truth in the statement that "The sire is more than half the herd." He is the more valuable half, however, only when his daughters are more satisfactory individuals and producers than are their mothers. It is highly desirable, therefore, to judge the dairy sire on the broadest possible basis. Individuality and pedigrees indicating purity and the best of breeding should both be given due consideration in judging. In the final analysis, much dependence may be placed on the value of the daughters of a bull—providing he has reached the age and maturity to have a number of them—in determining whether or not he is worthy of further use as a sire. A proven sire of this character is of great value.

USE ONLY BRED-FOR-PRODUCTION SIRE

A full consideration of a bull's pedigree with reference to his dam, granddams and great-granddams, and the milk and butter-fat production records of the daughters of his sire, grandsires and great-grandsires indicates to what extent a bull is "bred-for-production." A good pedigree is one of the essentials for judging the true value of a bull. Without a good pedigree there are chances for disappointment sooner or later in the development of a herd, due to the inheritance of weak characters that may have been common to animals in immediate or remote generations of ancestors.

PRESERVE THE PROVEN SIRES

The most valuable sires are good individuals—at least they are without serious objectionable features. They have good pedigrees indicating "bred-for-production" qualities; and their prepotency, or ability to produce, is marked. The daughters of a valuable sire are uniformly desirable and better than their dams—

or anyhow as good as an excellent lot of dams. Sires having these qualities should be continued in service to the fullest extent. Such excellence, prepotency and high value on the part of sires are rare qualities. In many instances they are not appreciated to the extent that men will seek to locate sires having these traits. Many sires are sold to the butcher before there is opportunity to judge fully their merits. Too much emphasis cannot be placed on the importance of exercising the best and most complete judgment possible in the selection of bulls for herd sires and on preserving and using proven sires to the fullest extent.

JUDGING AS AN ART

Judging dairy cattle in its relationship to the dairy industry may be regarded as a useful art. The careful dairyman who is anxious to build up the best possible herd will find it advantageous to study carefully the art of judging on the basis of individuality, pedigree and performance of cattle.

JUDGING IN THE SHOW RING

Show yard judging is confined to making awards on the basis of individuality and beauty of form as appreciated by the eye of the expert judge. A keen eye is needed for judging and is a necessity for the highest degree of success in stock breeding for "Beauty is bought by judgment of the eye." Show yard awards may not necessarily mean greatest production or "bred-for-production" individuals. There is no reason, however, why show yard animals cannot be a combination of beauty, choicest breeding, and high productive capacity. Such animals are becoming more common, and with such a combination of excellence are the most valuable class of animals to be found.

BECOMING A SHOW YARD JUDGE

One may learn a great deal and acquire much of the art of judging from books on the subject and by observing the work of expert judges whenever there is opportunity to do so. The best judges, however, are men who have owned or managed a first-class dairy herd, and who have made a careful study of judging in the show ring. Making careful and accurate observations and exercising judgment based on the best standards of excellence will assist more than any other thing in becoming an expert judge

of livestock. One should take advantage of every opportunity to observe the work of expert judges and to take part in scoring and judging exercises whenever possible.

SCORE CARDS OR SCALE OF POINTS

The dairy score card or scale of points is an enumeration of all parts of the cow, arranged in given order, with a statement of the requirements and the number of points for a perfect score of each part. The sum of the points for all parts totals 100. This arrangement is termed, "A scale of points" and is the standard of excellence by which the individuality of the cow with reference to her form and body characteristics may be judged. Each national dairy cattle breed association has a scale of points for its particular breed. It is well for the judge to have in mind the scale of points for the breed on which he is to pass judgment. Otherwise he may err seriously.

On account of the great amount of time required to go through the mechanical operation of scoring a large number of animals, the score card system of judging is not practiced at shows or in buying cows. The primary object of the scale of points is to systematically train the mind to give consideration and weight to each part of the animal in formulating a judgment. Score cards are furnished by dairy cattle breeders' associations and it is a splendid thing for local associations of dairymen and students of judging to have scoring exercises.

HOW TO CONDUCT A SCORING EXERCISE

Every community interested in the improvement of its dairy cattle might have one or more meetings each year for score card practice. Here are a few general rules: Choose someone with experience and a knowledge of correct dairy form for leader and demonstrator; have a sufficient number of animals to avoid having too many men crowd about and score the same one; have the animals stand at ease on a level floor or piece of ground provided with good light; inspect the cow from all directions at a distance of 10 to 16 feet noting carefully her size, form, quality and alertness, (too close contact with the animal often leads a judge to be deceived); note each point in the order it is named on the score card; use the hand only to determine the quality of the hair and hide, the secretion of the skin, the openness of the back, distance

apart of the ribs, the condition of the mammary veins and milk wells, and the quality of the udder.

The following rules may be employed to determine the extent to which any part should be cut. The cut for a deficiency never exceeds half of the total number of points allowed for perfection and is never less than .25 of one point. For example, the face is allowed 5 points for perfection and however deficient is never cut more than 2.5 nor less than .25 if deficient in the least. One's judgment must decide the amount of discount between these limits. No cut is made where no deficiency is noted. When all have completed their scores of the animal or group of animals, the leader or expert should read his score and call for comparisons and discussions on all parts of the animal to help everyone to arrive so far as possible at a proper judgment.

The scale of points shown on page 31 is used more especially in teaching elementary stock judging at the University of Wisconsin. It teaches the essential features and the structural requirements of the dairy cow. It applies to all dairy cows without reference to breed, and will be valuable to anyone interested in the selection and judging of cows, who is not familiar with what constitutes dairy types and the essential features of the dairy cow.

A scale of points for each dairy breed is also given on pages 32 to 43. These have been prepared by the respective breeders' associations and apply only to the breed of cattle for which each was prepared. They teach the size, color markings and peculiarities of form of the different breeds, as well as the essential features of a dairy cow. The breeder and judge of dairy cattle should thoroughly familiarize himself with the scale of points for the particular breed or breeds he may have occasion to judge.

JUDGING EXERCISES AND CONTESTS

When one becomes familiar with all the parts and essential features of the dairy cow, competitive judging or placing a group of animals in the order of their merit will be interesting and helpful in acquiring the art of judging. Judging exercises and contests can be held at meetings of cattle breeders' associations, county and state fairs, farmers' clubs, boys' clubs and various other meetings. Officials of local breed associations and fairs, county agricultural representatives, high school teachers of agri-

culture, leaders of boys' clubs and anyone else interested in the bettering of rural conditions can organize and hold judging contests.

A judging card is very helpful in placing competitive classes of animals. The card for dairy cattle shown below clearly indicates how one who has become familiar with essential features of dairy animals may proceed to judge and place four animals of a given class and feel that no important considerations have been overlooked. In referring to the card and making use of it, one should familiarize himself with all of the parts and characteristics of an animal that define feed capacity, dairy temperament and the other essential features, and then rate the class to be judged in the order that his judgment dictates.

The judging card is also arranged for grading the student or contestant as his work in placing a class of animals is checked with that of an expert judging committee. Judging exercises and contests will do much to arouse an interest in better classes of farm animals. Furthermore, such exercises will be the means of stimulating the power of observation, clear thinking and good judgment.

THE UNIVERSITY OF WISCONSIN
DAIRY CATTLE JUDGING CARD

Class..... *Date*.....

Student..... *No*.....

Placing	1st	2nd	3rd	4th	Student's Grade [1]
Feed capacity					
Dairy temperament					
Constitution					
Back and rump					
Milk organs					
Style and quality					
			Total Average		
Final placing of class					

Total
Student's final grade .....

SCALE OF POINTS FOR DAIRY CATTLE

Student..... *Date*.....
Animal..... *Animal*.....

GENERAL APPEARANCE—A dairy cow should weigh not less than 800 pounds, have large capacity for feed, a dairy temperament, well developed milk organs, fine quality and perfect health, and be capable of a large production of milk and butter fat.

SCALE OF POINTS	Perfect	Points deficient		Points deficient	
		Student's score	Corrected	Student's score	Corrected
INDICATION OF CAPACITY FOR FEED—25 POINTS					
Face, broad between the eyes and long; muzzle clean cut; mouth large; lips strong; lower jaws lean and sinewy	5				
Body, wedge shape as viewed from front, side and top; ribs, long, far apart and well sprung; breast full and wide; flanks, deep and full	10				
Back, straight; chine, broad and open; loin broad and roomy	5				
Hips and thurls, wide apart and high	5				
INDICATION OF DAIRY TEMPERAMENT—25 POINTS					
Head, clean cut and fine in contour; eyes, prominent, full and bright	3				
Neck, thin, long, neatly joined to head and shoulders and free from throatiness and dewlap	4				
Brisket, lean and light	2				
Shoulders, lean, sloping, nicely laid up to body; points prominent; withers sharp	4				
Back, strong, prominent to tail head and open jointed	3				
Hips, prominent, sharp and level with back	3				
Thighs, thin and incurving	4				
Tail, fine and tapering	1				
Legs, straight; shank fine	1				
INDICATION OF WELL DEVELOPED MILK ORGANS—25 POINTS					
Rump, long, wide and level; pelvis roomy	3				
Thighs, wide apart; twist, high and open	3				
Udder, large, pliable, extending well forward and high up behind; quarters, full, symmetrical, evenly joined and well held up to body	15				
Teats, plumb, good size, symmetrical and well placed	4				
INDICATIONS OF STRONG CIRCULATORY SYSTEM, HEALTH, VIGOR AND MILK FLOW—25 POINTS					
Eyes, bright and placid	2				
Nostrils, large and open	3				
Chest, roomy	5				
Skin, pliable; hair, fine and straight; secretions, abundant in ear, on body and at end of tail	7				
Veins, prominent on face and udder; mammary veins, large, long, crooked and branching; milk wells large and numerous	7				
Escutcheon, wide and extending high up	1				
Total	100				

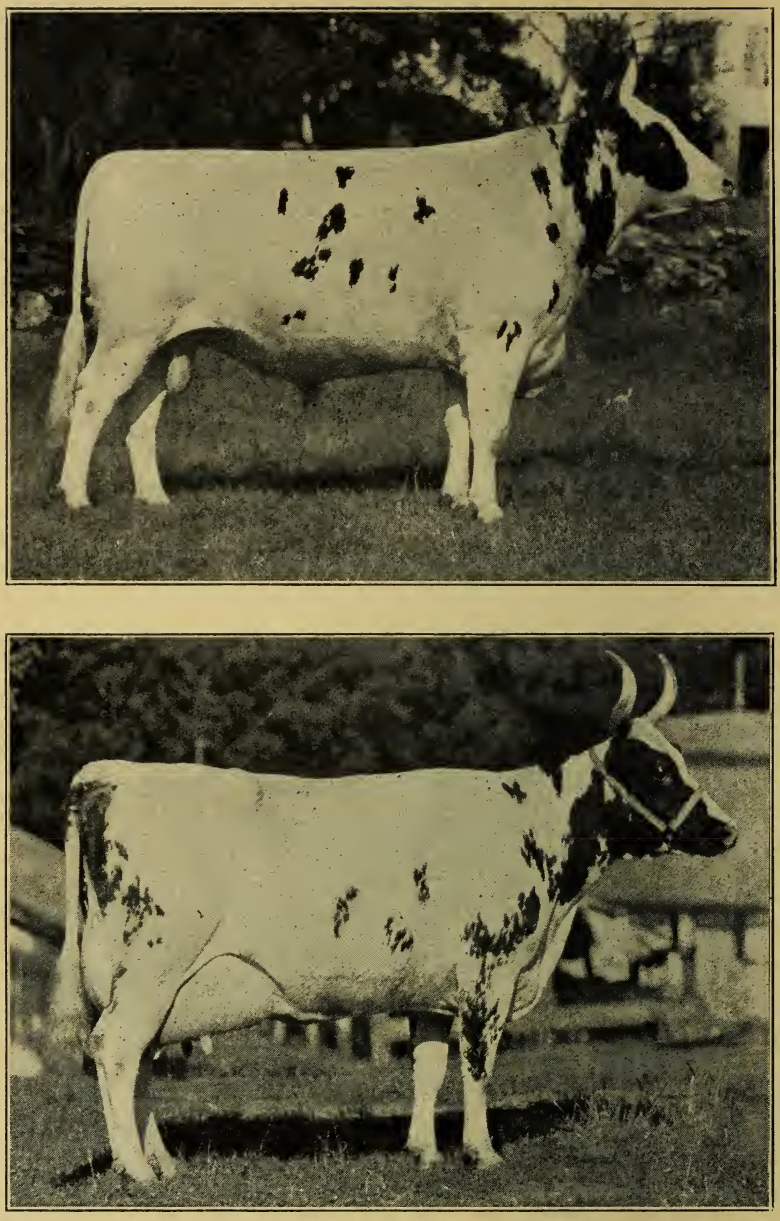


FIG. 17.—THE NOTED SCOTCH BREED

The native home of the Ayrshire is southwestern Scotland. Cattle of this breed were imported into Canada early in the 19th century and into the United States in 1822. The American Ayrshire Breeders' Association, organized in 1875, provides for the registration of Ayrshire cattle bred in the United States. C. L. Burlingham, Brandon, Vermont, is the present secretary.

The Ayrshire cow, Garclaugh May Mischief 27944, holds the world's milk record for this breed with a production of 25,329 pounds of milk testing 3.53 per cent, and 894.91 pounds of butter fat. Lily of Willowmoor has the highest butter fat record for the breed, with a production of 22,596 pounds of milk testing 4.22 per cent, and 955.56 pounds of butter fat.

Laurie Lorain 22202 holds the best Wisconsin record for the breed with a production of 16,753 pounds of milk testing 4.28 per cent. and 717.6 pounds of butter fat.

SCALE OF POINTS FOR AYRSHIRE COW

Head **10**
- Forehead—Broad and clearly defined 1
- Horn—Wide set on and inclining upward 1
- Face—Of medium length, slightly dished; clean cut, showing veins 2
- Muzzle—Broad and strong without coarseness, nostrils large 1
- Jaws—Wide at the base and strong 1
- Eyes—Full and bright with placid expression 3
- Ears—Of medium size and fine, carried alert 1

Neck.—Fine throughout, throat clean, neatly joined to head and shoulders, of good length, moderately thin, nearly free from loose skin, elegant in bearing **3**

Fore Quarters **10**
- Shoulders—Light, good distance through from point to point but sharp at withers, smoothly blending into body 2
- Chest—Low, deep and full between back and forelegs 6
- Brisket—Light 1
- Legs and Feet—Legs straight and short, well apart, shanks fine and smooth, joints firm, feet of medium size, round, solid and deep 1

Body **13**
- Back—Short and straight, chine lean, sharp and open jointed 4
- Loin—Broad, strong and level 2
- Ribs—Long, broad, wide apart and well sprung 3
- Abdomen—Capacious, deep, firmly held up with strong muscular development 3
- Flank—Thin and arching 1

Hind Quarters **11**
- Rump—Wide, level, long from hooks to pin bones, a reasonable pelvic arch allowed 3
- Hooks—Wide apart and not projecting above back nor unduly overlain with fat 2
- Pin Bones—High, wide apart 1
- Thighs—Thin, long and wide apart 2
- Tail—Fine, long and set on level with back 1
- Legs and Feet—Legs strong, short, straight, when viewed from behind and set well apart; shanks fine and smooth, joints firm, feet medium size, round, solid and deep 2

Udder.—Long, wide, deep but not pendulous, nor fleshy; firmly attached to the body, extending well up behind and far forward; quarters even; sole nearly level and not indented between teats, udder veins well developed and plainly visible **22**

Teats.—Evenly placed, distance apart from side to side equal to half the breadth of udder, from back to front equal to one-third the length; length 2½ to 3½ inches, thickness in keeping with length, hanging perpendicular and not tapering **8**

Mammary Veins.—Large, long, tortuous, branching and entering large orifices **5**

Escutcheon.—Distinctly defined, spreading over thighs and extending well upward **2**

Color.—Red of any shade, brown, or these with white; mahogany and white, or white, each color distinctly defined. (Brindle markings allowed but not desired.) **2**

Covering **6**
- Skin—Medium thickness, mellow and elastic 3
- Hair—Soft and fine 2
- Secretions—Oily, of rich brown or yellow color 1

Style.—Active, vigorous, showing strong character, temperament inclined to nervousness but docile **4**

Weight.—At maturity not less than 1,000 pounds **4**

Total **100**

SCALE OF POINTS FOR AYRSHIRE BULL

Head 16
- Forehead—Broad and clearly defined 2
- Horn—Strong at base, set wide apart inclining upward 1
- Face—Of medium length, clean cut, showing facial veins 2
- Muzzle—Broad and strong without coarseness 1
- Nostrils—Large and open 2
- Jaws—Wide at the base and strong 1
- Eyes—Moderately large, full and bright 3
- Ears—Of medium size and fine, carried alert 1
- Expression—Full of vigor, resolute and masculine 3

Neck.—Of medium length, somewhat arched, large and strong in the muscles on top, inclined to flatness on sides, enlarging symmetrically toward the shoulders, throat clean and free from loose skin 10

Fore Quarters 15
- Shoulders—Strong, smoothly blending into body with good distance through from point to point and fine on top 3
- Chest—Low, deep and full between back and forelegs 8
- Brisket—Deep, not too prominent and with very little dewlap .. 2
- Legs and Feet—Legs well apart, straight and short, shanks fine and smooth, joints firm, feet of medium size, round, solid and deep 2

Body 18
- Back—Short and straight, chine strongly developed and open jointed 5
- Loin—Broad, strong and level 4
- Ribs—Long, broad, strong, well sprung and wide apart 4
- Abdomen—Large and deep, trimly held up with muscular development 4
- Flank—Thin and arching 1

Hind Quarters 16
- Rump—Level, long from hooks to pin bones 5
- Hooks—Medium distance apart, proportionately narrower than in female, not rising above the level of the back 2
- Pin Bones—High, wide apart 2
- Thighs—Thin, long and wide apart 4
- Tail—Fine, long and set on level with back 1
- Legs and Feet—Legs straight, set well apart, shanks fine and smooth, feet medium size, round, solid and deep, not cross in walking 2

Scrotum.—Well developed and strongly carried 3

Rudimentaries, Veins, Etc.—Teats of uniform size, squarely placed, wide apart and free from scrotum; veins long, large, tortuous with extensions entering large orifices, escutcheon pronounced and covering a large surface 4

Color.—Red of any shade, brown, or these with white; mahogany and white, or white, each color distinctly defined 3

Covering 6
- Skin—Medium thickness, mellow and elastic 3
- Hair—Soft and fine 2
- Secretions—Oily, of rich brown or yellow color 1

Style.—Active, vigorous, showing strong masculine character, temperament inclined to nervousness but not irritable or vicious 5

Weight.—At maturity not less than 1,500 pounds 4

Total 100

SCALE OF POINTS FOR BROWN SWISS COWS AND HEIFERS

Head, medium size and rather long	2
Face, dished, narrow between horns and wide between eyes	2
Ears, large, fringed inside with light colored hair, skin inside of ear a deep orange color	2
Nose, black, large and square with mouth surrounded by mealy colored band, tongue black	2
Eyes, moderately large, full and bright	2
Horns, short, regularly set with black tips	2
Neck, straight, throat clean, neatly joined to head, shoulders of good length, moderately thin at the withers	4
Chest, low, deep and full between and back of fore legs	6
Back, level to setting of tail and broad across the loin	6
Ribs, long and broad, wide apart and well sprung from thin, arching flanks	3
Abdomen, large and deep	5
Hips wide apart, rump long and broad	4
Thighs, wide, quarters not thin	4
Legs, short and straight with good hoofs	2
Tail, slender, well set on, with good switch	2
Hide of medium thickness, mellow and elastic	3
Color, shades from dark to light brown, at some seasons of the year grey; white splashes near udder not objectionable, light stripe along back. White splashes on body or sides objectionable. Hair between horns usually lighter shade than body	4
Fore udder, wide, deep, well rounded but not pendulous, nor fleshy, extending far forward on the abdomen	12
Rear udder, wide, deep, but not pendulous, nor fleshy, extending well up behind	12
Teats, rather large, set well apart and hanging straight	8
Milk, veins large, long, tortuous, elastic and entering good wells	6
Disposition quiet	2
Size, evidence of constitution, and stamina	5
	100

SCALE OF POINTS FOR BROWN SWISS BULL

Head, same as cow	2
Face, same as cow	2
Expression, full of vigor, resolution and masculinity	3
Ears, same as cow	2
Nose, same as cow	2
Eyes, same as cow	2
Horns, same as cow	2
Neck, of medium length, somewhat arched, large and strong in muscles on top, sloping symmetrically to shoulders. Shoulders large and strong, smoothly blending into body	10
Chest, same as cow	10
Back, same as cow	10
Ribs and abdomen, same as cow	10
Hips, same as cow	6
Thighs, same as cow	6
Legs, same as cow	2
Tail, same as cow	2
Hide, same as cow	3
Color, same as cow	4
Scrotum well developed and strongly carried	3
Rudimentary teats, squarely placed wide apart and free from the scrotum	6
Milk veins, same as cow	6
Disposition quiet	3
Size, evidence of constitution and stamina	4
	100

Dark, smoky skins very objectionable.

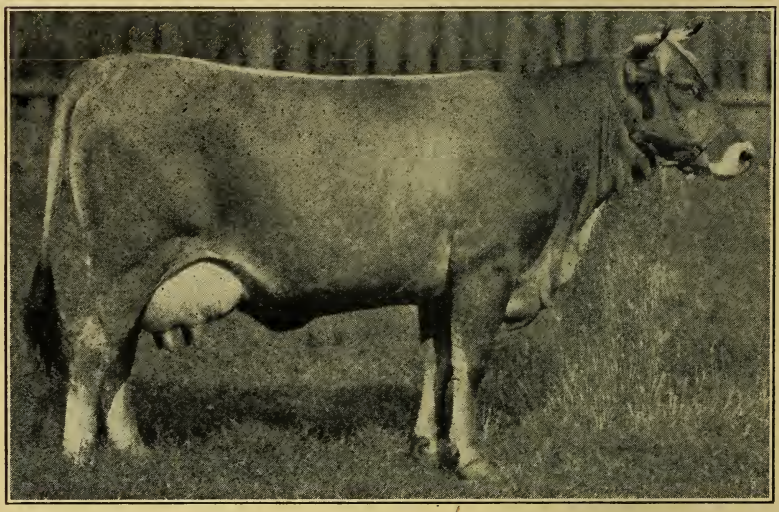


FIG. 18.—ORIGINALLY FROM SWITZERLAND

Brown Swiss cattle were first imported into America from Switzerland, their native home, in 1869. The Brown Swiss Cattle Breeders' Association of America was organized in 1880 and promotes the interests of the breed in this country. Ira Inman, Beloit, Wisconsin, is the present secretary.

College Bravura 2d 2577 holds the world's record for this breed with 19,460.6 pounds of milk testing 4.10 per cent, and 798.16 pounds of butter fat. Flora Duwire 4105, highest production Wisconsin cow of this breed, made 16,538.1 pounds of milk testing 3.193 per cent, and 649.42 pounds of butter fat.

SCALE OF POINTS FOR GUERNSEY COW

Head.—Clean cut, lean face, wide mouth and muzzle with open nostrils, full bright eye with gentle expression. Forehead long, broad between the eyes and dishing 6

Horns.—Small at base, medium length, not too spreading 1

Neck.—Long and thin; clean throat 2

Withers.—Chine rising above shoulder blades, that are moderately thick and not coarse 3

Back.—Straight from withers to hips 8

Hips.—Wide apart, not too prominent 2

Rump.—Long, continuing with level of the back, also level between hip bones and pin bones 5

Thurls.—Wide apart and high 2

Chest.—Wide, and deep at heart, with least depression possible back of the shoulders 4

Body.—Deep and long, with well-sprung ribs which are wide apart. Broad loin. Thin arching flank 10

Thighs.—Thin, incurving seen from side, and wide apart from rear .. 2

Legs.—Comparatively short, clean, wide apart and nearly straight when viewed from behind, squarely set under body 2

Hide.—Loose and pliable, and not thick, with oily feeling 3

Tail.—Neat and firm setting on, long, good switch 1

Udder 18
Veins prominent 2
Attachment to body long and wide 2
Extending well forward 5
Level and well up behind 4
Teats of good even size, well apart and squarely placed 5

Milk Veins.—Long, crooked, branching and prominent, with large, deep wells 4

Secretions Indicating Color of Product.—Indicated by depth of yellow, inclining toward orange in the pigment secretion in the skin, on the body generally, and especially discernible in the ear, at the end of bone of tail, around the eye, on the udder and teats and at the base of horns. Hoofs and horns amber colored 20

Color Markings.—A shade of fawn with white markings 2

Size.—Mature cows about 1100 pounds in milking condition 5

100

SCALE OF POINTS FOR GUERNSEY BULL

Head.—Clean cut, lean face, wide mouth and muzzle, with open nostrils, and full bright musculine eye. Broad between the eyes and dishing 8

Horns.—Small at base, medium length, not too spreading 1

Neck.—Long masculine neck with strong crest and clean throat 4

Withers.—Chine rising above shoulder blades, that are moderately thick and not coarse 3

Back.—Straight from withers to hips 8

Hips.—Wide apart, not too prominent 2

Rump.—Long, continuing with level of the back, also level between hip bones and pin bones 6

Thurls.—Wide apart and high 2

Chest.—Wide and deep at heart, least depression possible back of shoulders 6

Body.—Deep and long, with well-sprung ribs which are wide apart. Thin arching flank 10

Thighs.—Thin, incurving seen from side, and wide apart from rear .. 2

Legs.—Comparatively short, clean, wide apart and nearly straight when viewed from behind, squarely set under body 2

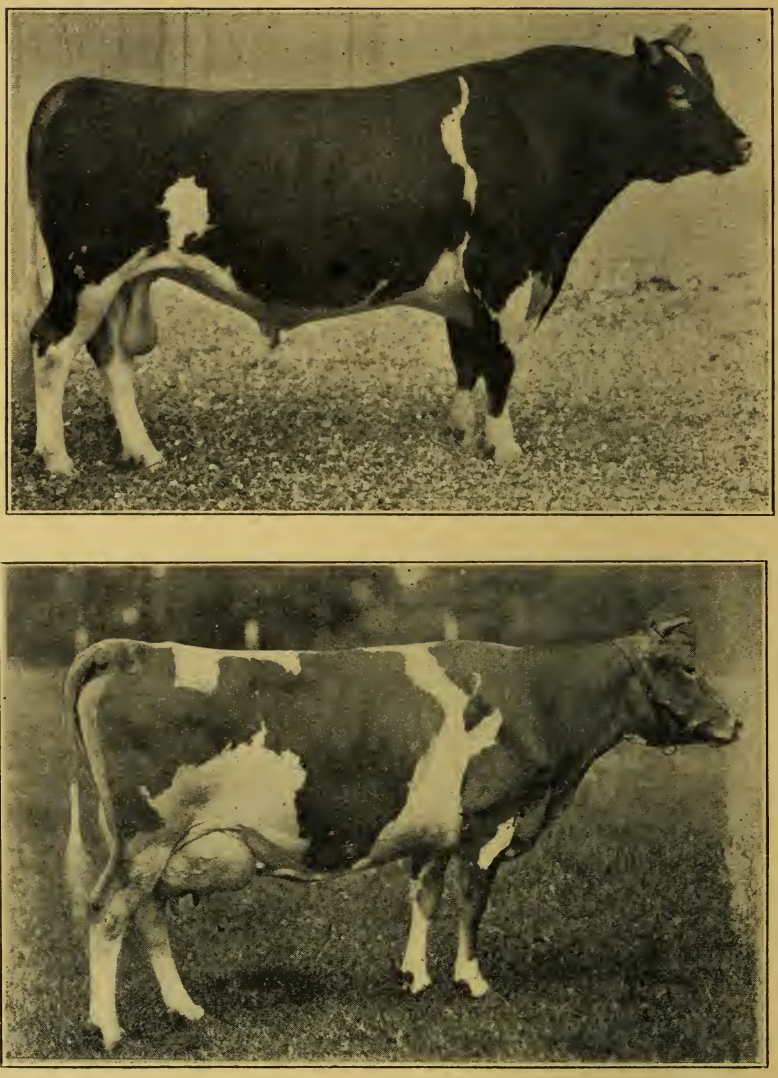


FIG. 19.—ONE OF THE CHANNEL ISLAND BREEDS

Guernseys have their origin in the Islands of Guernsey and Alderney, off the coast of France in the English Channel. They were imported into America as early as 1818, but not until 1893 did wide public interest in this breed develop. The American Guernsey Cattle Club was organized in 1877. William H. Caldwell, Peterboro, New Hampshire, is the present secretary.

Murne Cowan 19597 holds the world's milk record for this breed with a production of 24,008 pounds of milk testing 4.57 per cent, and 1,098.18 pounds of butter fat. Countess Prue 43785 is the highest record Guernsey in butter fat production. Her record is 18,626.9 pounds of milk and 1,103.28 pounds of butter fat.

Yeksa's Tops of Gold's Fannie 22362 is the highest production Wisconsin cow of the breed, with a record of 19,794.9 pounds of milk testing 4.64, and 981.53 pounds of butter fat.

Hide.—Loose and pliable, and not thick, with oily feeling..... 5

Tail.—Neat and firm setting on, long, good switch..... 1

Rudimentary Teats.—Teats wide apart and squarely placed..... 3

Milk Veins.—Long, crooked, branching and prominent, with large, deep wells 5

Secretions Indicating Color of Product.—Indicated by depth of yellow, inclining toward orange, of the pigment secretion of the skin on the body generally and especially discernible in the ear, at the end of bone of tail, around the eye, on the scrotum, and inside of thighs, and at base of horn. Hoofs and horns amber colored..... 20

Color Markings.—A shade of fawn with white markings..... 5

Size.—Mature bulls about 1,600 pounds..... 7

100

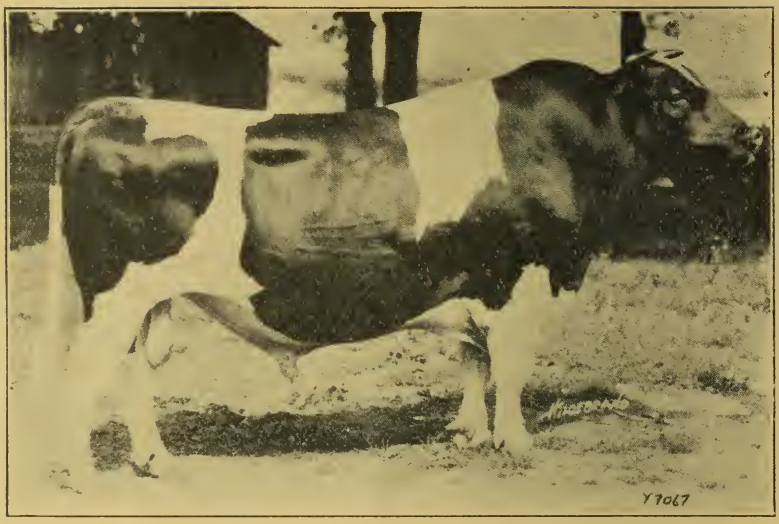


FIG. 20.—FIRST BRED TO MEET FRIESLAND'S NEEDS

The native home of the Holstein-Friesian cattle is in North Holland. Their introduction into America dates back to the 17th century. The Holstein-Friesian Association of America was organized to promote the breed in 1885. F. L. Houghton, Brattleboro, Vermont, is the present secretary. M. H. Gardner, Delavan, Wisconsin, supervises the registration of Advanced Registry animals.

The Holstein-Friesian cow, Segis Pietertje Prospect 221846, holds the world's milk record with a production of 37,381.4 pounds of milk testing 3.10 per cent, and 1,158.95 pounds of butter fat. Bella Pontiac 46321 C. H. B. of this breed holds the world's butter fat record with a production of 27,017.0 pounds of milk testing 4.66 per cent, and 1,258.40 pounds of butter fat.

Champion Dora Korndyke 134002 holds the Wisconsin record for the breed with a production of 29,395.7 pounds of milk testing 3.58 per cent, and 1,052.75 pounds of butter fat.

SCALE OF POINTS FOR HOLSTEIN-FRIESIAN COW

Head.—Decidedly feminine in appearance; fine in contour	2
Forehead.—Broad between the eyes; dishing	2
Face.—Of medium length; clean and trim, especially under the eyes; showing facial veins; the bridge of the nose straight	2
Muzzle.—Broad, with strong lips	1
Ears.—Of medium size; of fine texture; the hair plentiful and soft; the secretions oily and abundant	1
Eyes.—Large; full; mild; bright	2
Horns.—Small; tapering finely towards the tips; set moderately narrow at base; oval; inclining forward; well bent inward; of fine texture; in appearance waxy	1
Neck.—Long; fine and clean at juncture with the head; free from dewlap; evenly and smoothly joined to shoulders	4
Shoulders.—Slightly lower than the hips; fine and even over tops; moderately broad and full at sides	3
Chest.—Of moderate depth and lowness; smooth and moderately full in brisket; full in the foreflanks (or through at the heart)	6
Crops.—Moderately full	2
Chine.—Straight, strong; broadly developed, with open vertebrae	6
Barrel.—Long; of wedge shape; well rounded; with a large abdomen, trimly held up. (In judging the last item age must be considered.)	7
Loin and Hips.—Broad; level or nearly level between the hookbones; level and strong laterally; spreading from chine broadly and nearly level; hookbones fairly prominent	6
Rump.—Long; high; broad with roomy pelvis; nearly level laterally; comparatively full above the thurl; carried out straight to dropping of tail	6
Thurl.—High, broad	3
Quarters.—Deep; straight behind; twist filled with development of udder; wide and moderately full at the sides	4
Flanks.—Deep; comparatively full	2
Legs.—Comparatively short; clean and nearly straight; wide apart; firmly and squarely set under the body; feet of medium size, round, solid and deep	4
Tail.—Large at base, the setting well back; tapering finely to switch; the end of the bone reaching to hocks or below; the switch full	2
Hair and Handling.—Hair healthful in appearance; fine, soft and furry; the skin of medium thickness and loose; mellow under the hand; the secretions oily, abundant and of a rich brown or yellow color	8
Mammary Veins.—Very large; very crooked (age must be taken into consideration in judging of size and crookedness); entering very large or numerous orifices; double extension; with special developments, such as branches, connections, etc	10
Udder.—Very capacious; very flexible; quarters even; nearly filling the space in the rear below the twist; extending well forward in the front; broad and well held up	12
Teats.—Well formed; wide apart; plumb and of convenient size	2
Escutcheon.—Largest; finest	2
Perfection	100

SCALE OF POINTS FOR HOLSTEIN-FRIESIAN BULL

Head.—Showing full vigor; elegant in contour	2
Forehead.—Broad between the eyes; dishing	2
Face.—Of medium length; clean and trim, especially under the eyes; the bridge of the nose straight	2
Muzzle.—Broad, with strong lips	1
Ears.—Of medium size; of fine texture; the hair plentiful and soft; the secretions oily and abundant	1
Eyes.—Large; full; mild; bright	2
Horns.—Short; of medium size at base; gradually diminishing towards tips; oval; inclining forward; moderately curved inward; of fine texture; in appearance waxy	1
Neck.—Long; finely crested (if the animal is mature); fine and clean at juncture with the head; nearly free from dewlap; strongly and smoothly joined to shoulders	5

Shoulders.—Of medium height; of medium thickness, and smoothly rounded at tops; broad and full at sides; smooth over front..... 4

Chest.—Deep and low; well filled and smooth in the brisket; broad between the forearms; full in the foreflanks (or through at the heart) 7

Crops.—Comparatively full; nearly level with the shoulders..... 4

Chine.—Strong; straight; broadly developed, with open vertebrae.... 6

Barrel.—Long; well rounded; with large abdomen, strongly and trimly held up..... 7

Loin and Hips.—Broad; level or nearly level between hookbones; level and strong laterally; spreading from the chine broadly and nearly level; the hookbones fairly prominent..... 7

Rump.—Long; broad; high; nearly level laterally; comparatively full above the thurl; carried out straight to dropping of tail..... 7

Thurl.—High; broad 4

Quarters.—Deep; broad; straight behind; wide and full at sides; open in the twist..... 5

Flanks.—Deep; full 2

Legs.—Comparatively short; clean and nearly straight; wide apart; firmly and squarely set under the body; arms wide, strong and tapering; feet of medium size, sound, solid and deep..... 5

Tail.—Large at base, the setting well back; tapering finely to switch; the end of bone reaching to hocks or below; the switch full..... 2

Hair and Handling.—Hair healthful in appearance; fine, soft and furry; skin of medium thickness and loose; mellow under the hand; the secretions oily, abundant and of a rich brown or yellow color.. 10

Mammary Veins.—Large; full; entering large orifices; double extension; with special development, such as forks, branches, connections, etc. 10

Rudimentary Teats.—Large; well placed..... 2

Escutcheon.—Largest; finest 2

Perfection 100

SCALE OF POINTS FOR JERSEY COW

Head **7**

A. Medium size, lean; face dished; broad between eyes; horns medium size, incurving..... 3

B. Eyes full and placid; ears medium size, fine, carried alert; muzzle broad, with wide open nostrils and muscular lips; jaw strong 4

Neck.—Thin, rather long, with clean throat, neatly joined to head and shoulders **4**

Body 37

A. Shoulders light, good distance through from point to point, but thin at withers; chest deep and full between and just back of fore legs..... 5

B. Ribs amply sprung and wide apart, giving wedge shape, with deep, large abdomen, firmly held up, with strong muscular development 10

C. Back straight and strong, with prominent spinal processes; loins broad and strong..... 5

D. Rump long to tail-setting, and level from hip-bones to rump-bones 6

E. Hip-bones high and wide apart..... 3

F. Thighs flat and wide apart, giving ample room for udder.... 3

G. Legs proportionate to size and of fine quality, well apart, with good feet, and not to weave or cross in walking..... 2

H. Hide loose and mellow..... 2

I. Tail thin, long, with good switch, not coarse at setting-on.. 1

FIG. 21.—ANOTHER CHANNEL ISLAND BREED

The native home of Jersey cattle is on the Island of Jersey in the English Channel. Jersey cattle were imported into America as early as 1818. The American Jersey Cattle Club was organized in 1868. R. M. Gow, 324 West Twenty-third St., New York City, is the present secretary.

Eminent's Bess 209719, with a production of 18,783 pounds of milk testing 5.12 per cent, and 962.80 pounds of butter fat, holds the world's milk record for this breed. Plain Mary 268206 holds the world's fat record for this breed with a production of 15,255 pounds of milk testing 6.82 per cent, and 1,040 pounds of butter fat.

Trinket's Ebony L. 292925 is the highest production Wisconsin cow of tne breed with a record of 14,112.2 pounds of milk testing 5.38 per cent, and 759.17 pounds of butter fat.

Udder 26
- A. Large size, flexible and not fleshy 6
- B. Broad, level or spherical, not deeply cut between teats 4
- C. Fore udder full and well rounded, running well forward of front teats 10
- D. Rear udder well rounded, and well out and up behind 6

Teats.—Of good and uniform length and size, regularly and squarely placed 8

Milk Veins.—Large, long, tortuous and elastic, entering large and numerous orifices 4

Size.—Mature cows, 800 to 1,000 pounds 4

General Appearance.—A symmetrical balancing of all the parts, and a proportion of parts to each other, depending on size of animal, with the general appearance of a high-class animal, with capacity for food and productiveness at pail 10

100

SCALE OF POINTS FOR JERSEY BULL

Head 10
- A. Broad, medium length; face dished; narrow between horns; horns medium in size and incurving 5
- B. Muzzle broad, nostrils open, eyes full and bold; entire expression one of vigor, resolution and masculinity 5

Neck.—Medium length, with full crest at maturity; clean at throat 7

Body 57
- A. Shoulders full and strong, good distance through from point to point, with well-defined withers; chest deep and full between and just back of fore legs 15
- B. Barrel long, of good depth and breadth, with strong, rounded, well-sprung ribs 15
- C. Back straight and strong 5
- D. Rump of good length and proportion to size of body, and level from hip-bones to rump-bones 7
- E. Loins broad and strong; hips rounded, and of medium width compared with female 7
- F. Thighs rather flat, well cut up behind, high arched flank 3
- G. Legs proportionate to size and of fine quality, well apart, with good feet, and not to weave or cross in walking 5

Rudimentary Teats.—Well placed 2

Hide.—Loose and mellow 2

Tail.—Thin, long, reaching the hock, with good switch, not coarse or high at setting-on 2

Size.—Mature bulls, 1,200 to 1,500 pounds 5

General Appearance.—Thoroughly masculine in character, with a harmonious blending of the parts to each other; thoroughly robust, and such an animal as in a herd of wild cattle would likely become master of the herd by the law of natural selection and survival of the fittest 15

100

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Bulletin 336

October, 1921

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FARM POULTRY BUILDINGS

AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF WISCONSIN
MADISON

Digest

If the house is dry and well ventilated the poultry flock will produce in extremely cold weather.

Page 3

Ventilation is necessary. A solid glass front house is hot during the day and cold at night.

Page 8

Length of working day for the hen controls production. Arrange the glass windows to obtain sunlight over the entire floor.

Page 9

The poultry house should be large enough to accommodate the flock during the winter. Overcrowding lowers egg production.

Pages 9-10

Does frost collect on the ceiling? Put in a straw loft over the roosts.

Page 16

All the fixtures should be at least two feet above the floor. This leaves the entire floor available for scratching.

Pages 17-18

The kind of a house and not the cost of a house determines the profit which the flock can make.

Pages 21-30

Farm Poultry Buildings

J. G. Halpin, J. B. Hayes and O. R. Zeasman

To succeed with poultry, provide a suitable house—one that is dry, light, airy, clean, and free from drafts and sudden changes in temperature. Hens must be comfortable if they are to be good producers.

On many farms the poultry is housed in an old building originally made for some other purpose—such as a granary, a machine shed, or a woodshed. Using such a house, as a rule, is not economical because it is difficult to remodel it to meet the needs of the flock.

Build the house on a hillside or a well-drained place, so that the floor and yards will be dry; otherwise the flock is likely to become diseased. Hens can withstand extremely cold, dry air but not dampness.

Poultry houses should be conveniently near to other farm buildings, but a site should be chosen where the hens will naturally range toward the field rather than toward the house. Hens remain near the house and barn to get shade and feed, but the use of an orchard for a shady range and the practice of feeding the hens at the poultry house will tend to keep them away from the farmhouse.

If possible, build the house on ground that slopes to the south and face it in that direction so the poultry will get the greatest amount of sunshine on short winter days.

A windy place is not desirable for the poultry house. If no other site is available trees and shrubs should be planted to break the force of the wind and afford shelter to the house—especially during fall and spring when the winds are strong. One side of the orchard can often be chosen as a site for the poultry house, as it makes an ideal range during part of the year.

COLONY HOUSE SYSTEM

In the colony house system only one flock or one colony is kept in a building.

Colony houses are of two types—the portable and the non-portable. The portable type is especially adapted to growing

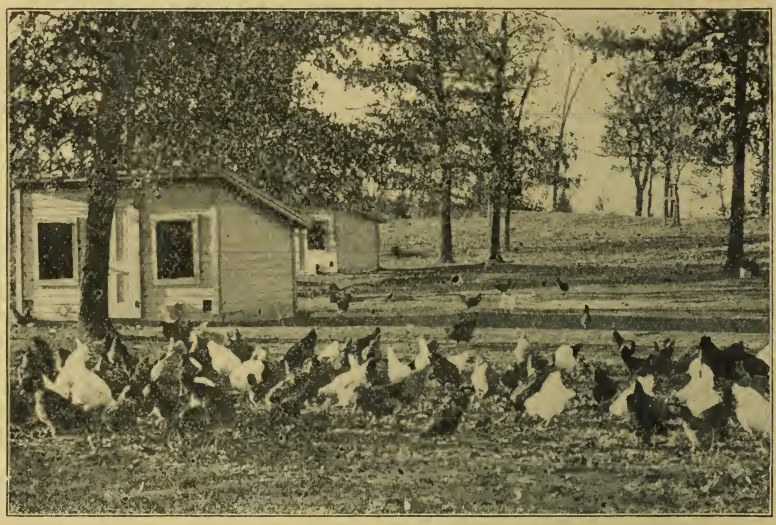

FIG. 1.—PORTABLE 8′x12′ COLONY HOUSE

An ideal portable house for rearing young stock on range and for small special matings during the breeding season.

young stock. The usual method is to nail the house on runners and have a team draw it from place to place.

This type of house saves much feed which otherwise would be wasted in the fields because after the crop has been harvested the house and chickens can be moved into the field. In this way poultry is always kept on clean ground and gets more insects than would be possible if it were kept around the farm buildings. In some years, especially when grasshoppers are numerous, chicks out in the field will pick their living and also rid the farm of troublesome insects.

On some of the larger farms where considerable poultry is kept, it is possible to keep the chickens in portable colony houses all their lives. The young stock is started while the houses are near the farm buildings so that it can be protected from enemies. As the chicks get older they can be moved farther from the build-

ings out into the field. Toward fall the houses are drawn in near the farm buildings and placed close together so that they can be cared for easily throughout the winter.

A small house of the non-portable type is often used on the general farm, but the hens abuse the pullets in the fall when all the chickens are put in one colony. Moreover, with this type of house there is no chance to select the best laying and most vigorous females. Therefore it is necessary to keep enough males to fertilize the eggs of the entire flock.

THE LONG HOUSE SYSTEM

Long houses with or without cross partitions, are used on many large poultry farms. They are less expensive to build, and less labor is required to care for the fowls, as the poultry man can go from one pen to another more quickly than from one

FIG. 2.—LONG POULTRY HOUSE AT WISCONSIN COLLEGE OF AGRICULTURE

Practical commercial type for a breeder of several varieties. A single unit makes a good house for a farm flock.

detached house to another. Long houses have the ground more closely stocked so that there is much less natural feed such as insects and green grass.

As large numbers of chickens are kept closely together, the tendency to disease is greater. The grounds and buildings need more careful watching to keep them sanitary.

Where many hens are kept together, the tendency to form bad habits, such as egg eating, is much more pronounced.

The long house with partitions across it is usually to be preferred to the long house without partitions. If there are several

partitions in a house one can divide the hens with advantage and treat them much more as colonies of chickens are treated.

METHODS OF YARDING

With this type of house several methods of yarding can be used. A good method is shown in Figure 3. In this diagram each pen has a separate yard on the south where the stock is allowed to run in fall and early spring. The north side is left as an open field in which the hens run during summer after the breeding season. Since they are used to their pens, the majority return to their own places without trouble. While they are in the north yard, the south yard is cultivated and sown to a crop of buckwheat and rye to sweeten the ground and to furnish fall and spring pasture. This sowing should be done in June or early in July. The space directly north of the house is more likely to become contaminated, so that it is desirable to grow a crop of some kind on this each year. Corn or sunflowers are often grown in the yards to furnish shade.

The principal thing is to keep the ground constantly cultivated to get rid of filth.

Unless the chickens are given free range the continuous house without partition should be yarded on both north and south. This type of house is less expensive, as there are no inside fences in the yard. The chief trouble with this system is that the hens crowd to the end of the house at feeding time unless only hopper feeding is done. An expert can handle a large flock,

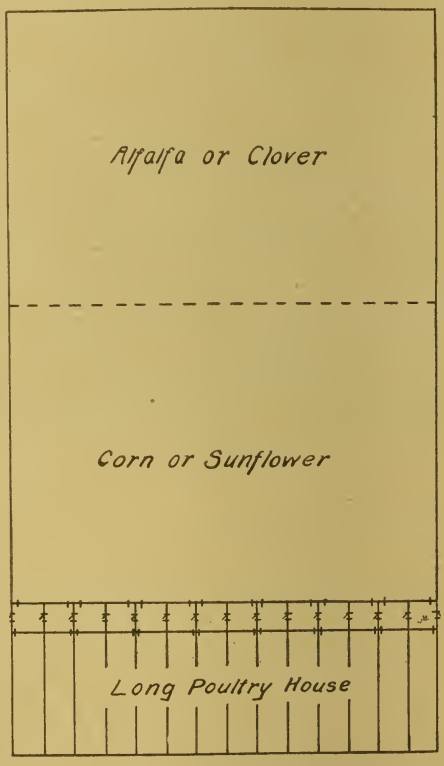

FIG. 3.—CULTIVATE THE POULTRY YARD

Fruit trees or corn provide summer shade and cultivation keeps the soil clean. Green feed, such as oats or clover, should be planted.

but an amateur might better care for fewer hens and give each one more attention.

Farmers who keep only a few chickens, as well as large poultry plant owners, can use the small portable houses for growing chicks. They are especially good for pullets, which develop much better on free range than when closely confined. Many Wisconsin farmers have adopted portable colony houses for brooding.

The general farm on which only a few chickens are kept should have a divided house. In this way it is possible to make up the breeding pens from the best hens and pullets in the spring, and then later to allow all to run together if advisable. In either case it is better to fence in the hens that are not kept for breeding purposes and give the breeding flock free range of the farm. No matter what system is used, always encourage the hens to range near their house and away from the other farm buildings. To do this keep the house clean. It pays to store the feed in the poultry house so that the hens will expect to be fed from there and not from the barn.

Feeding fowls from the back porch teaches them to come to the house where they are pests. All the kitchen scraps used for poultry feed should be put in a pail, carried to the poultry house and fed in a clean place or in clean troughs near the house.

FENCING THE YARD

Confining the hens in a small yard is another common mistake. Frequently a little more fence could be used around the garden and house and the hens kept where desired yet allowed abundant range. At times a rather closely-woven field fence could be put around the orchard and thus give the hens plenty of room without much added expense. A low fence will confine hens when they are allowed a good sized range but a high fence is necessary where the range is small.

VENTILATION

A poultry house usually needs more ventilation than it gets. Fresh air is far more important than warmth. Fresh air means health, but must never be supplied by a draft. The hen was never intended to live in a house. A tree is her natural home; but the northern winters are so cold that it is impossible to get eggs from hens roosting in trees as it takes all they can eat to

keep them alive. The poultry house then, should furnish protection from storms and cold winds and yet give freedom to the hen. Both feeding floor and roosting place should be dry and

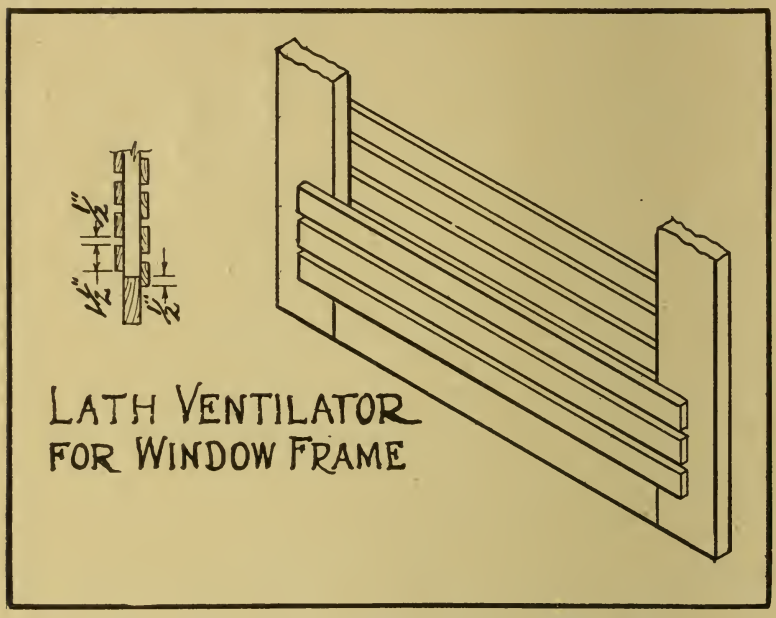

FIG. 4.—THE LATH BAFFLER IS SELF-OPERATING

clean. If a house is damp in winter it is usually because there is not enough ventilation; and more fresh air must be admitted to carry out the dampness and bad air.

There are three common ways of ventilating a poultry house. The King system, or a form of it, is the most general but its success depends upon the location of the other farm buildings. When the low poultry house is placed between higher farm buildings such as a house and barn a dead air space results with no draft through the outlet flue.

Muslin or burlap may be used to replace another window. When this is used the dust must be swept off regularly and the windows opened during the day to air out the house. Use 1 square foot of cloth to 15 square feet of floor space.

The baffler is a new ventilator that has been giving good results. It is a modification of the old-fashioned shutters formerly used on houses. They were not suitable because too much cold air was allowed to enter the house, but the present construction (see Fig. 4) allows the poultry to receive a constant supply of

fresh air without a draft. Common building laths are used as shown in the diagram. The bafflers are used during the winter and removed in summer. They are made so that they need almost no attention except to open the windows during the day. Allow 1 square foot of baffler to 20 square feet of floor space.

Glass Windows

A poultry house should have about 1 square foot of glass to every 10 or 12 square feet of floor space. Thus for a 20x20 poultry house one needs 40 square feet of glass. The window pane should be the same size as those already in use in the barn and other buildings as it is a decided advantage to have all the windows uniform. The usual size is 8″x10″ or 10″x12″.

Windows should reach from within 2 feet of the floor to 6 inches or 1 foot from the plate. This is the only way to spread light evenly over the floor of the house.

Windows should be made to open in readily from the top to admit fresh air during mild winter days. A window that opens at the top is best as there is less draught on the hens.

Glass windows should be cleaned frequently because egg production depends to a decided extent on the length of the day. If the windows are clean the hens will be off the roost early in the morning and stay off late at night which will mean more eggs. In summer the glass windows should be taken out and stored where they will not be broken. The window space should always be covered on the outside with 1-inch mesh chicken wire to keep out sparrows and owls.

The Size of the House

The size of the house depends upon the number of fowls that are to be kept in one pen, and the fact that they should be confined constantly during the winter.

Fowls, as a rule, are kept too crowded for best results. A flock of fifty hens should be allowed about 4 square feet of floor space per hen. If the house is kept clean and the floor heavily littered with straw, less floor space will be needed. In general, too much floor space is far better than too little. The larger the pen, the less floor space will be required for each hen.

(Fig. 5.) One hundred hens will thrive in a pen 20x20 feet—that is, 4 square feet of floor space per hen—but one hen will not thrive in a pen 2x2 feet. In the large pen, each one may wander over the entire floor space and thus get more exercise. As the number in the flock decreases the amount of floor space per hen must increase. Anyone keeping eight or ten hens should allow at least 10 square feet of floor space per hen, unless he will give special attention to cleaning and bedding the house. A crowded poultry house causes poor winter egg production on many farms.

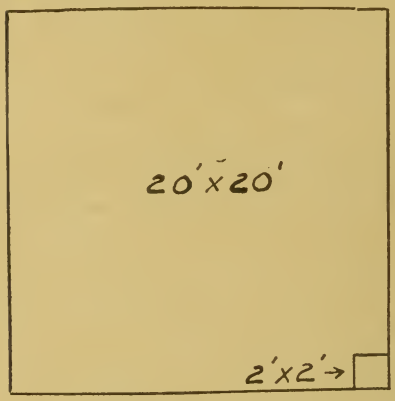

FIG. 5.—OVERCROWDING DECREASES PRODUCTION

Cull the flock to fit the house; 100 hens may live but cannot produce in a house designed for 50.

Farm hens are frequently kept at the rate of about one square foot of floor space per hen. Where hens have access to the barnyard, straw stack, and feed lots, the amount of floor space per hen is not so important because the house then becomes a roosting place and the barnyard is the feeding floor. When a farm flock is increased the hens are often too closely kept. When 80 hens are kept in a house which is large enough for only 40, the results are discouraging. It is always best to sell some of the hens rather than to keep more than the house will hold satisfactorily.

THE WIDTH OF THE HOUSE

It is far cheaper, as a general rule, to build a wide house than a narrow one. A house 20x20 is cheaper than one 10x40 and contains as much floor space for the hens. The house should be between 16 and 20 feet deep. The deeper it is the warmer the roosting quarters will be in winter and the cooler in summer.

TYPES OF ROOFS

Several common types of roofs are used on poultry houses—(Fig. 6.) The style is largely a matter of choice but the type of roof affects the cost of building to quite an extent.

Shed Roof. A shed roof or "one slant," (Fig. 6-1) is the

most common and requires less cutting of rafters. It turns all the water to the north leaving the south or front dry and warm. In building a shed roof wider than 14 feet, heavy material should be used for rafters or else supporting beams should

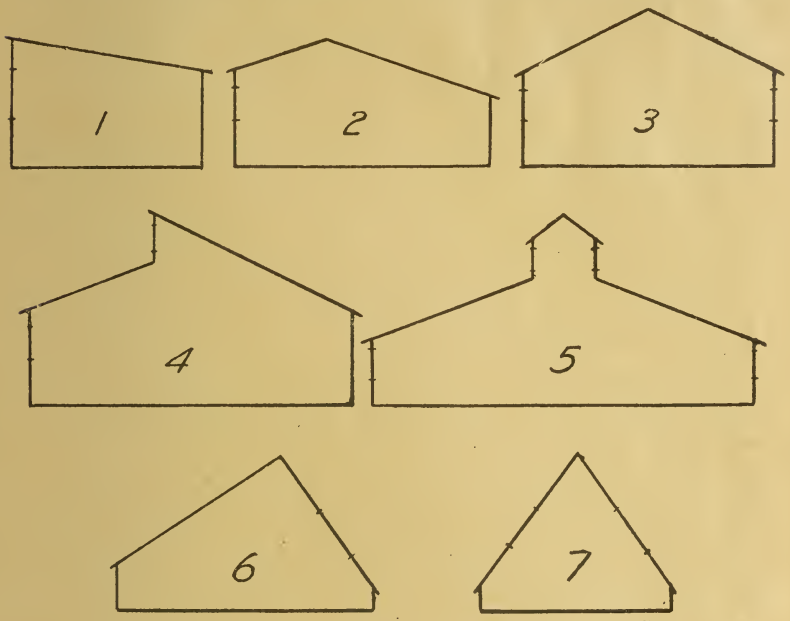

FIG. 6.—TYPES OF ROOFS FOR POULTRY HOUSES

1. Shed. 2. Combination. 3. Gable. 4. Semi-monitor. 5. Monitor. 6. Slanting front. 7. A-shaped. The first three are the really practical types for most farm poultry houses.

be run lengthwise throughout the house. The roof on the poultry house, as a rule, is built rather flat, not over one-fifth pitch. A shed roof also gives a low rear elevation which makes the house warm, but has disadvantages in some locations as the high front catches strong south winds, and also heats up rapidly during sunny winter days. Most of the prepared roofings last longer on a north slope, and, therefore, are particularly adapted to the shed roof type.

Combination Roof. The roof shown in Fig. 6-2 is a modification of the shed roof but is more attractive, giving the same low elevation in the rear and a lower elevation in front. This roof can be built wider and is especially valuable in houses more than 14 feet wide. Built with the same pitch of roof and with the same elevation in the rear this house contains less air space and is, therefore, warmer than the shed roof type. In construct-

ing this roof it is usually better to build the gable back one-third of the way from the front. That is, on a house 18 feet wide the gable should be 6 feet back from the front. This type of roof should be used more extensively than it now is.

Gable Roof. The gable roof shown in Fig. 6-3 is a common type often used because it matches the other buildings on the farm. This roof permits the house to be built in any desired width, but gives more air space and therefore tends to make the poultry house cold. That is, too high a rear elevation is needed to get the front high enough to admit sunshine and to allow for a door. The air space of such a house may be decreased by putting a ceiling from plate to plate, placing the boards so that about one inch space is left between each. Then cover this with about one foot of straw so that the air can circulate readily from the pen up through the straw. To make this complete, cut a small door or window in each gable end and keep these windows open except during severe storms. This will be found the best way to remodel many of the old gable roof houses.

Semi-Monitor Roof. This type (Fig. 6-4) is practical and often used. Many of the old narrow shed roof houses are remodeled by building an addition on the south side forming a roof of this type which is better adapted to a small stationary house than to a long one. It is unsuitable for a continuous house as the south side is built so low that it is practically impossible to clean out the litter without carrying it to the end of the building. It is possible with this type of roof to reduce the air space and thus to admit sunshine into the back of the pen, making a very practical small poultry house. Many times the south side needs only to be covered with wire.

TYPES OF FOUNDATIONS

Portable colony houses should be built on two runners either of 4x4 material, or better, two small trees of small durable wood flattened on top and tapered off at both ends. Usually it is better to treat the runners with some wood preservative before building the house and then stand them on blocks or stones to keep them off the ground. Some poultrymen use 2x4 pieces spiked together, and as fast as the lower one rots, it is removed and a new one

spiked fast. A stationary house should have a 3-foot cement wall as a foundation.

Where rats are troublesome a substantial cement foundation is a good investment. This should always be brought from 6 inches to a foot above the surface and then filled in with coarse material such as gravel. In extremely wet locations, especially in clay soil, it often pays to excavate under the entire house and replace with stones or other coarse material, and then connect with tile drains to remove all the water from under the house. In places where stones are abundant, poultry houses are put on stone walls, but unless cement is used to fasten the stones together securely, rats will often work under the house and do a great deal of damage. A loose stone wall is an ideal dwelling place for rats and should never be placed under a poultry house.

Kinds of Floors

In many localities a sand or dirt floor is cheap and advisable. Hens like a dirt floor if it is dry. It makes a natural dust wallow but must be replaced often in order to keep the house sanitary. A dirt floor must always be well above the outside surface so that the water drains away leaving the floor dry and comfortable for the fowls. Where a cement foundation is used for the house, one can frequently tamp the surface hard and then fill in to the top of the foundation with sand. This sand should be replaced each year before cold weather.

A cement floor is much easier to keep clean and is durable and rat proof. A cement floor should never be left bare but should be kept constantly covered with at least three inches of sand and with from six to ten inches of straw in winter. When sand cannot be had, extra care should be taken to keep the floor heavily littered so that none of it becomes bare.

A cement floor should always be just even with the top of the foundation so that the entire surface is smooth and easily cleaned. Where cement floor and foundation are placed in the house, it is usually better to put in the floor before building the house. The best method is to dig a trench for the foundation, fill it with concrete, erect the forms to the desired height and fill with concrete. As soon as the foundation is at all hard, remove the form from the inside and immediately fill with cinders if available. Tamp

hard and quickly lay the cement floor as shown in Fig. 7. By building the cement floor while the foundation is green the floor and the foundation become well fastened together and absolutely rat proof.

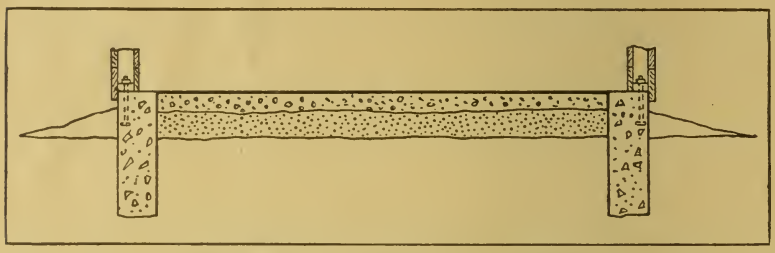

FIG. 7.—PROPERLY CONSTRUCTED CONCRETE FLOOR

Keep the top of the floor 8 to 12 inches above the surrounding ground for proper drainage.

WALLS OF THE POULTRY HOUSE

Poultry house walls must keep out rains, snow, and cold winds. They must also be reasonably durable and not too expensive. The walls on the north, east, and west are made wind-tight to prevent drafts. Cement blocks have been used but do not give universal satisfaction. Solid cement walls should never be used in a poultry house as they become damp and frost covered.

Most poultry houses are built with wooden walls. It is usual to use 2x4's about two feet apart for studding and either matched lumber or rough lumber with roofing paper or battens to make the wall wind-proof. Matched lumber, like drop siding, is usually placed on horizontally and is used quite extensively as such a house looks good and can be built rapidly. Matched siding of any kind should be dry, well driven together and well nailed so as to be wind-proof. All matched lumber used in this way should be of good grade and free from loose knots or other defects. One-ply roofing paper placed between the siding and studding adds warmth and insures a wind-proof wall.

Many old poultry houses are built with rough boards running up and down and the cracks covered with battens. This is not good because the battens become loose and leave cracks which are very undesirable. Rough boarding, either perpendicular or horizontal, is also being used widely. When covering rough

boards with roofing paper cement the joints thoroughly and batten them with thin strips at least every two feet. Cover the entire surface with two coats of good paint. Other walls are built by nailing rough boarding to the outside of the studding, covering with tar building paper, and then with ordinary siding such as is often used on houses. With any of these materials a tight wall can be constructed.

Selecting Roofing Material

Prepared roofing materials are proving very satisfactory. Many houses have such flat roofs that shingles are not desirable. Two or three-ply roofing paper is cheaper and, especially on a flat roof, is more advisable. Where the roof is somewhat steep and shingles of good quality can be purchased they will be found to be more durable. When prepared roofings are used, it is always best to use a good grade of boards for the roof. Hemlock shiplap makes a smooth, tight surface on which prepared roofing can be laid easily. Roofing materials last much longer on a smooth surface of this kind and will pay for the extra cost.

Materials for Partitions

In a small house—that is, one not over 30 feet long—use boards for the partitions for about 2 feet up from the floor. The rest may be of wire except between the roosts of the different pens where the boards should run to the roof. A solid partition at the back prevents draft on the fowls when roosting and a solid partition at the bottom prevents fighting.

In very long houses it is desirable to put in solid partitions, either for each pen or at intervals of about forty feet according to the size of the pen and the location of the building. In a windy location solid partitions will be found necessary more often in order to cut down the draft.

Long houses should have doors in each partition arranged in a straight line and hung with double action hinges. In a long poultry house—over 100 feet—a trolley system makes it easier to care for the fowls.

FIG. 8.—AN OLD HOUSE BROUGHT UP TO DATE

Three additional sash on this house improved the lighting, gave better ventilation, and increased production. A damp, dark house is one cause of disease.

THE STRAW LOFT

When the baffler does not control the ventilation and frost collects on the ceiling, put in a straw loft. Build a frame either of wire or of loose poles about two or three feet above the roosts and extending their full length. The frame should extend out in front of the roosts about a foot. Fill the space to the roof with loose straw. Fasten wire across the front of this loft to prevent hens nesting there. This straw pack will absorb excess moisture, prevent frost, and keep the house dry.

In the spring remove the straw, otherwise it will act as a hiding place for mites. The straw loft combined with the baffler gives excellent results.

ARRANGING INTERIOR FIXTURES

The interior should be arranged to make it easy to clean the house and care for the fowls.

Perches. All the perches should be on the same level because otherwise the fowls will fight to roost on the highest and many of them will be hurt by falling off. Perches should be in the warmest part of the pen so that the hens will not be cold during the night when they are inactive. If perches are removable it is easier to clean and disinfect them as well as to fight mites.

Small hens, as a general rule, should have about 6 inches of perch space and larger hens should be allowed 8 inches. In winter, hens huddle closer together but in summer they should have plenty of room. Perches should be 12 to 14 inches apart and not closer than 14 inches to the wall or ceiling. Show birds, especially Leghorns, or similar types, should be kept farther from the walls and ceilings. Many good birds are spoiled by "brooming" their tails against the walls.

Movable perches may be made in several ways. A common method is to hinge them to the wall at the back. If these hinges are made with loose pins the entire set of perches can be readily removed. The perch itself should not be fastened to the supporting cross piece but should be set into notches as shown in Fig. 9. A frame covered with one-inch mesh wire should be fastened under the perches to keep the hens from getting access to the droppings. This will also catch any eggs laid at night; and by keeping the hens from dropping boards, cleaner market eggs will result.

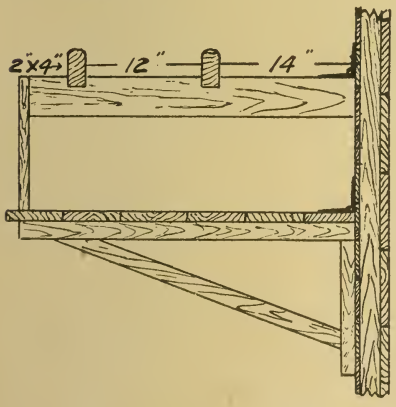

FIG. 9.—HINGED PERCHES AND DROPPING BOARD

Fasten the roosts against the wall during the day to keep the hens busy on the floor.

Dropping Boards. If the hens are fed inside the house in winter, place boards under the perches to catch the manure. This keeps the floor clean so that it can be used for feeding. When no dropping boards are used, a wide board should be placed in front of the perches on the floor to keep the litter away from the droppings under the roost. Dropping boards increase the size of the feed floor and must be cleaned often because they are close to the fowls, but if the manure is properly handled enough fertilizer is

saved to pay for the extra labor. A clean poultry house means healthy fowls. On the general farm, dropping boards may be used in the fall and winter and kept clean without great difficulty.

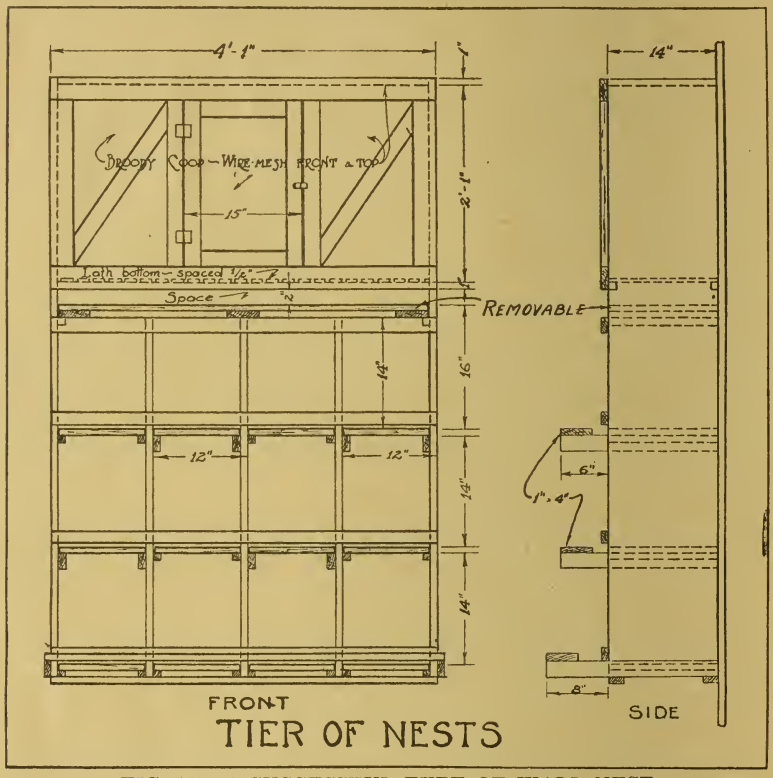

FIG. 10.—A SUCCESSFUL TYPE OF WALL NEST

In the spring, when other farm work is pressing, they may be removed because the hens are running at large and are no longer fed in the poultry house. Where this system is used the boards must be removed in the spring and not left to accumulate a large amount of droppings as this would be unhealthful for the poultry. A hinged roost and dropping board is shown in Fig. 9. This is a good arrangement because the droppings are cleaned each morning and then the perches and board may be swung out of the way giving the hens a clear open space. This method is used in the long poultry house at the University of Wisconsin.

Nests. Every poultry house should have plenty of nests. They should be easy to get at and readily removed for cleaning and disinfecting.

The nests may be placed under the front edge of the dropping board, and so arranged that the hens enter from the rear and the poultryman gathers the eggs by opening a door or doors on the front side.

The objections to this plan are that the floor under the dropping boards is of little use in feeding and also is dark so that the hens are more likely to lay in the straw on the floor than in the nests. The result often is that eggs are not gathered for several days.

In most poultry houses the purpose of the dropping boards is defeated if the nests are placed below them. This means that a larger house must be planned, as the exercising space for each is reduced because the hens will not utilize the dark space back of the nests. The best arrangement is to have the nests on the wall.

A common plan is to fasten small open boxes to the walls of the poultry house. If the boxes become infested with mites, the entire box can be burned and new ones used. This method does not allow trap nesting, and the nests are not dark, yet it is used widely by poultrymen.

There are several good types of wall nests, some darkened and others not. Figure 10 shows a successful type.

A nest for a Leghorn or other small hen should be 12 inches square; for the larger varieties, 14 inches square. The nest should give at least 12 inches head room and be about 14 inches high. With an average flock, one nest to four or five hens is enough. Nests should be kept clean and well bedded with fine straw or hay. Shavings or excelsior may stain the eggs. Coarse straw and other harsh materials are not good because a hen likes a pliable, soft substance in the nest.

Watering Devices. Water should be in a convenient place. It is best to make a small stand about one foot above the floor and put the water dish on this. The water stand should be in a light place where it is convenient to empty the dish and refill it. The water dish will keep cleaner, as a rule, if it is near the south side of the building.

A low pail or a pan is a convenient water dish. Care should be taken to use only watering devices that can be readily cleaned. A dirty drinking dish is often a source of disease.

FIG. 11.—USE THE DOOR AS A WINDOW

The inner door should be short enough to swing over the litter. The outer screen door keeps the hens confined and furnishes summer ventilation.

FIG. 12.—SANITATION IN THE POULTRY HOUSE

An elevated stand for the water pan keeps the litter dry and the water clean. The grit and shell hopper are also available.

Dust Bath. In the winter a dust bath should be placed near an open window so that the sun shines on it during a part of the day. A common box filled with fine sand or sifted coal ashes, and road dust makes a good dust bath. In a house which has a dry sand floor or a cement floor covered with three or four inches of fine sand, a dust bath is seldom needed because the hens will wallow in the sand on the floor.

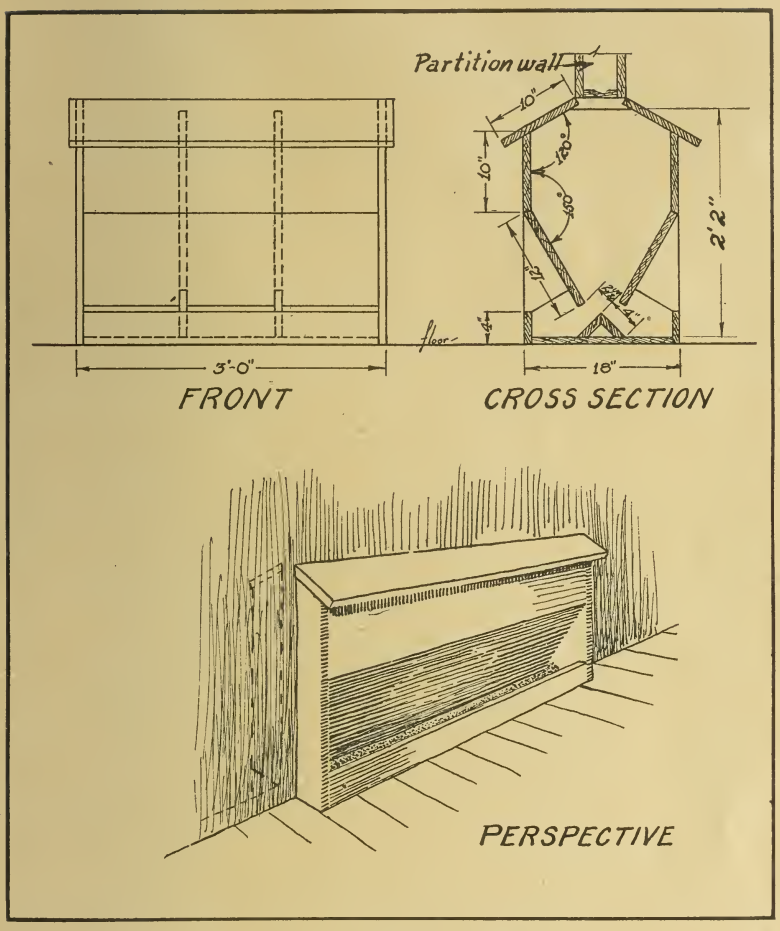

FIG. 13.—FEED HOPPER

The use of a self-feeder increases egg production.

BILL OF MATERIAL FOR FEED HOPPER

Use	No. Pieces	Dimensions	Board Ft.
Hinged doors (top)	1	1"x10"x6'	5
Vertical wall	1	1"x10"x6'	5
Sloping wall	1	1"x12"x6'	6
Bottom	1	1"x 8"x6'	4
Trough wall	1	1"x 4"x6'	2
Deflection boards	1	1"x 4"x6'	2
Ends	1	1"x 6"x16'	8
Partitions	1	1"x 8"x10'	6 ⅔

Four 1½-inch hinges.

BILL OF MATERIAL FOR 8'x8' PORTABLE POULTRY HOUSE

Use	No. Pieces	Dimensions	Board Ft
Skids	4	4"x4"x8'	42 2/3
Plates	2	2"x4"x8'	10 2/3
Sills	4	2"x4"x8'	21 1/3
Studding	1	16'	
Studding	2	10' } 2"x4"	48
Studding	3	12'	
Side sheathing		1" shiplap (8")	144
Outside cleats		115' of ½"x3" dressed	
Flooring		1" D. and M. (4")	64
Rafters	4	2"x4"x10'	26 2/3
Roof sheathing		1" shiplap (8")	90
Facia boards		38' 1"x4" (dressed)	12 2/3
	1	1"x12"x16' (dressed) }	26
	2	1"x 6"x10' (dressed) }	
Dropping boards		1" shiplap (6")	16
Braces	2	2"x4"x8'	10 2/3
Roost	1	2"x4"x8'	5 1/3
Door	1	1¼"x6"x16' dressed	16
Door trim	1	1"x4"x16'	5 1/3

Paper—260 square feet.
Window—1—1' 8"x2' 11"—6 light single sash—milled.
Wire mesh, 5 square feet.

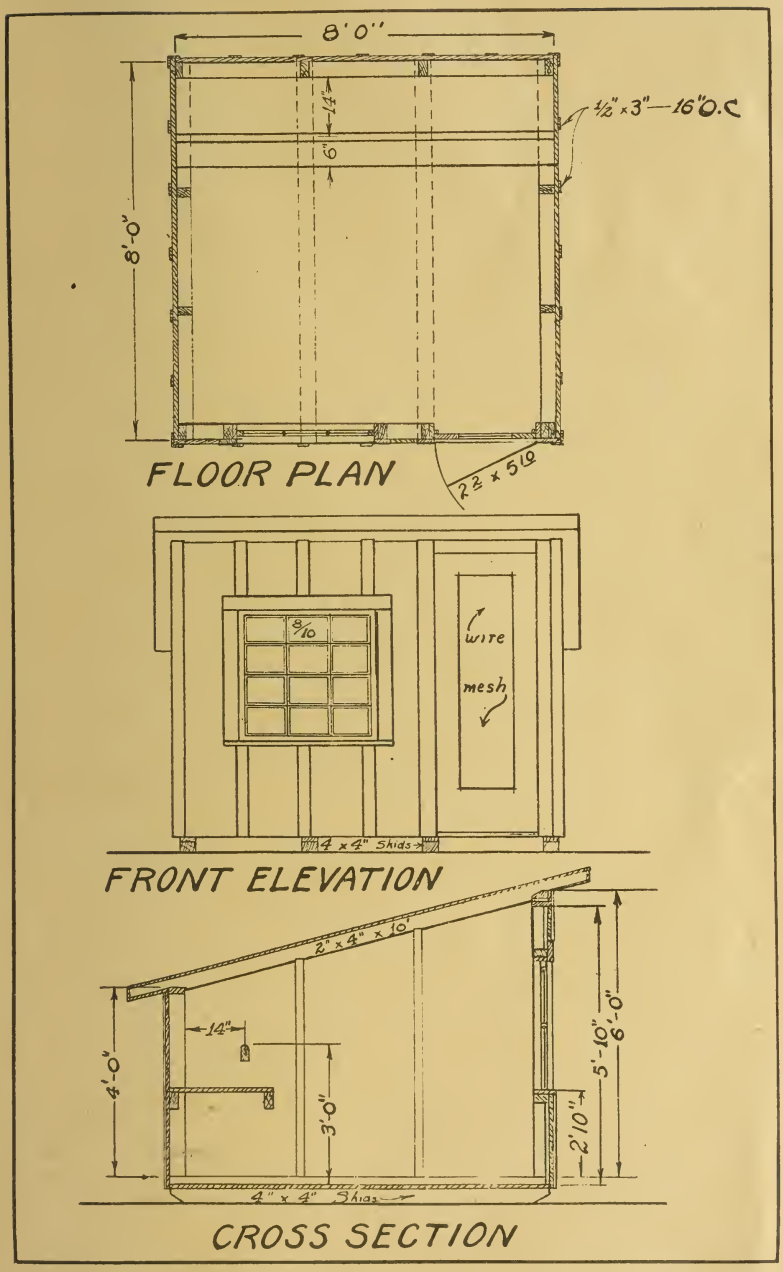

FIG. 14.—A GOOD PLAN FOR AN 8x8' COLONY HOUSE

Even small lots of chickens should be given proper housing.

BILL OF MATERIAL FOR 12'x16' POULTRY HOUSE

(Fig. 15)

Use	No. Pieces	Dimensions	Board Ft.
Studding	9	2"x4"x12'	72
Studding	6	2"x4"x18'	72
Rafters	7	2"x4"x16'	74 2/3
Collar beam	5	2"x4"x12'	40
Plates	8	2"x4"x16'	85 1/3
Plates	6	2"x4"x10'	40
Roofing		1"x8"	284
Siding (outside)		1" shiplap (8")	360
Siding (inside)		1"x6"	370
Corner boards		56' of 1"x4" dressed	18 2/3
Straw loft		1"x8"	160
Roosts	2	2"x4"x16'	21 1/3
Dropping boards		1"x8"	45
Dropping board frames	1	2"x4"x16'	10 2/3
Dropping board frames	2	2"x4"x12'	16
Baffler frames	2	1"x4"x16'	10 2/3

Concrete—83 cu. ft. floor and foundation.
Windows—4—2' 0"x4' 8"—2 sash—4 light—milled.
Doors—3—2' 2"x6' 4"—milled.
Nests and feed hopper not included.

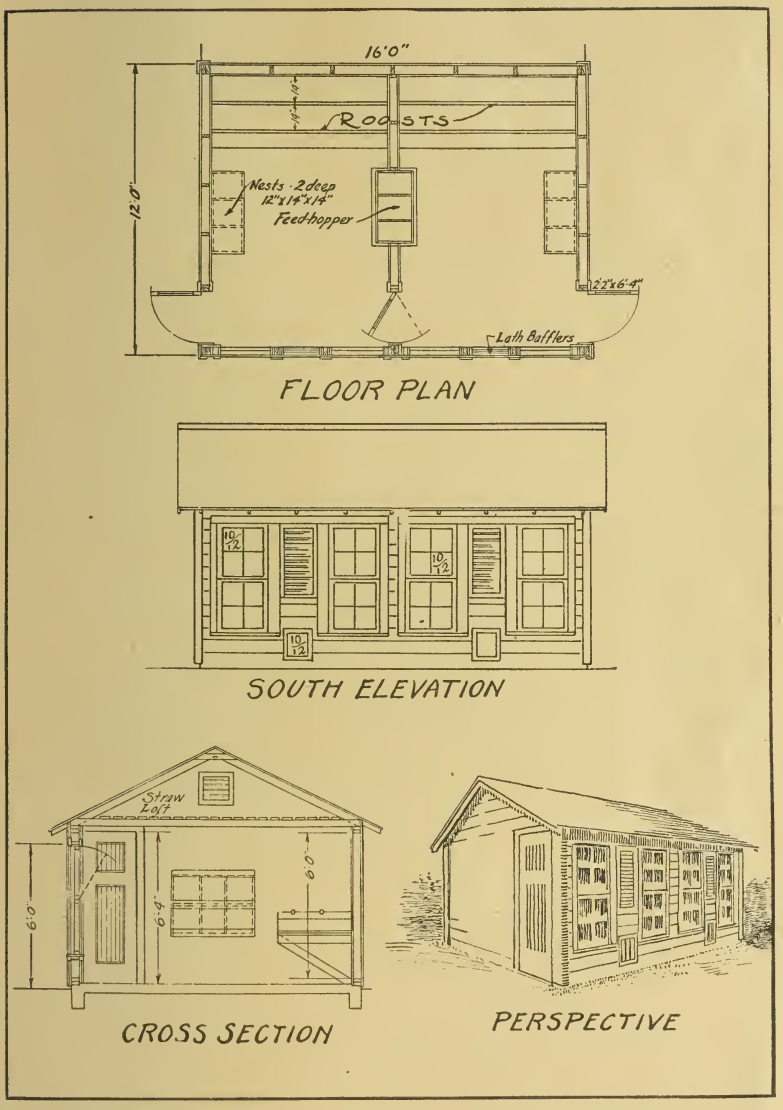

FIG. 15.—POULTRY HOUSE SUITABLE FOR A TOWN LOT

A two-pen house allows one to carry a breeding flock.

BILL OF LUMBER FOR COLONY HOUSE 8'x12'

(Fig. 16)

Use	No. Pieces	Dimensions	Board Ft.
Studding	4	2"x4"x10'	26 2/3
Studding	4	2"x4"x14'	37 1/3
Studding	3	2"x4"x12'	24
Rafters	8	2"x4"x10'	53 1/3
Roofing		1"x8"	136 sq. ft.
Plates	8	2"x4"x12'	64
Plates	3	2"x4"x16'	32
			T. & G. Flooring
Floor		1"x4"	96 sq. ft.
Corner boards	2	1"x4"x16'	10 2/3
Corner boards	2	1"x4"x12'	8
Facia boards*	2	1"x6"x14'	14
		56 sq. '	cloth for screen
Facia boards	2	1"x6"x14'	10
Facia boards	2	1"x10"x14'	23 1/3
Facia boards	2	1"x10"x20'	16 2/3
			Matched siding
Siding		1"x6"	276 sq. ft.

Windows—2—2' 4"x4' 0"—2 sash—6 light—milled.
Door—1—2' 6"x6' 0" milled. Does not include skids.
*May be omitted if open facia are desired.

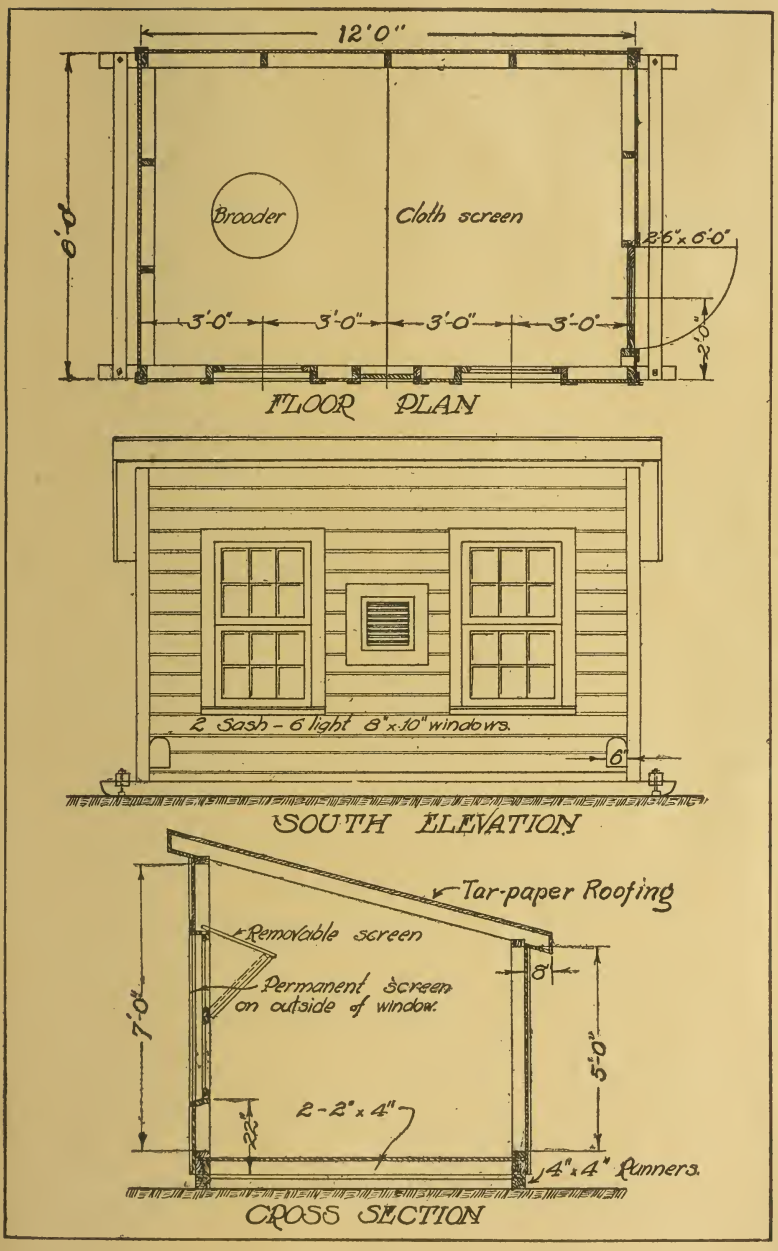

FIG. 16.—AN 8x12' COLONY HOUSE

Every farm should have a house of this type for brooding chicks or for special mating flocks.

BILL OF MATERIAL FOR WISCONSIN POULTRY HOUSE 20'x20'

(Figs. 17A, 17B)

Use	No. Pieces	Dimensions	Board Feet
Studding	16	2"x4"x14'	149 1/3
Studding	3	2"x4"x18'	36
Brace	4	2"x8"x10'	53 1/3
Rafters	22	2"x4"x12'	176
Roof boards		1"x8"	576 sq. ft.
Siding		1"x6"	523 sq. ft.
Windows	9	6 light 8"x10" sash.	
Bafflers	3	1"x4"x10'	10
Straw loft	5	2"x4"x10'	33 1/3
Straw loft	12	1"x8"x10'	80
Roosts	4	2"x4"x20'	53 1/3
Dropping boards		1"x8"	100 sq. ft.
Dropping boards		2"x4"x12'	24

Concrete, 245 cubic feet.
Nests, feeder and water stand not included.
Sand bath cover, 4 sashes—8 light 6"x6" with frame 9'x2'.

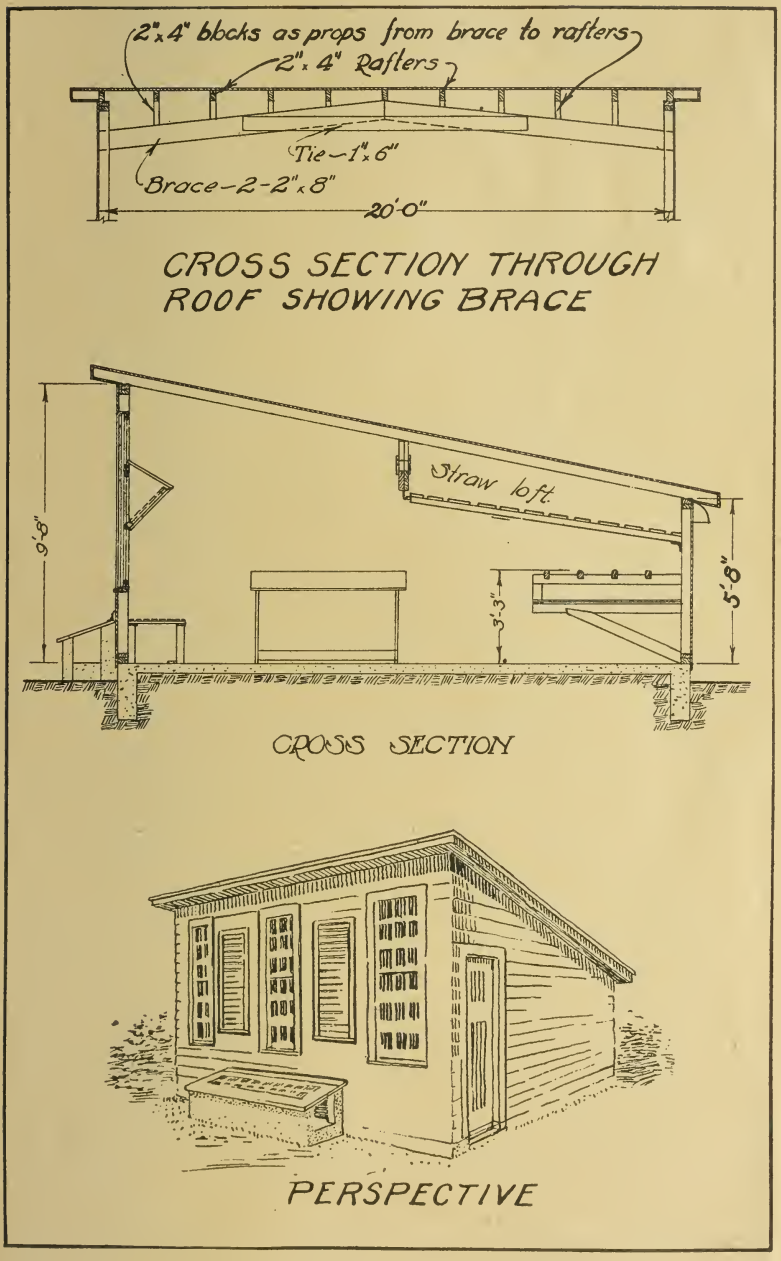

FIG. 17A.—100-HEN UNIT HOUSE

This type is adapted to Wisconsin farms

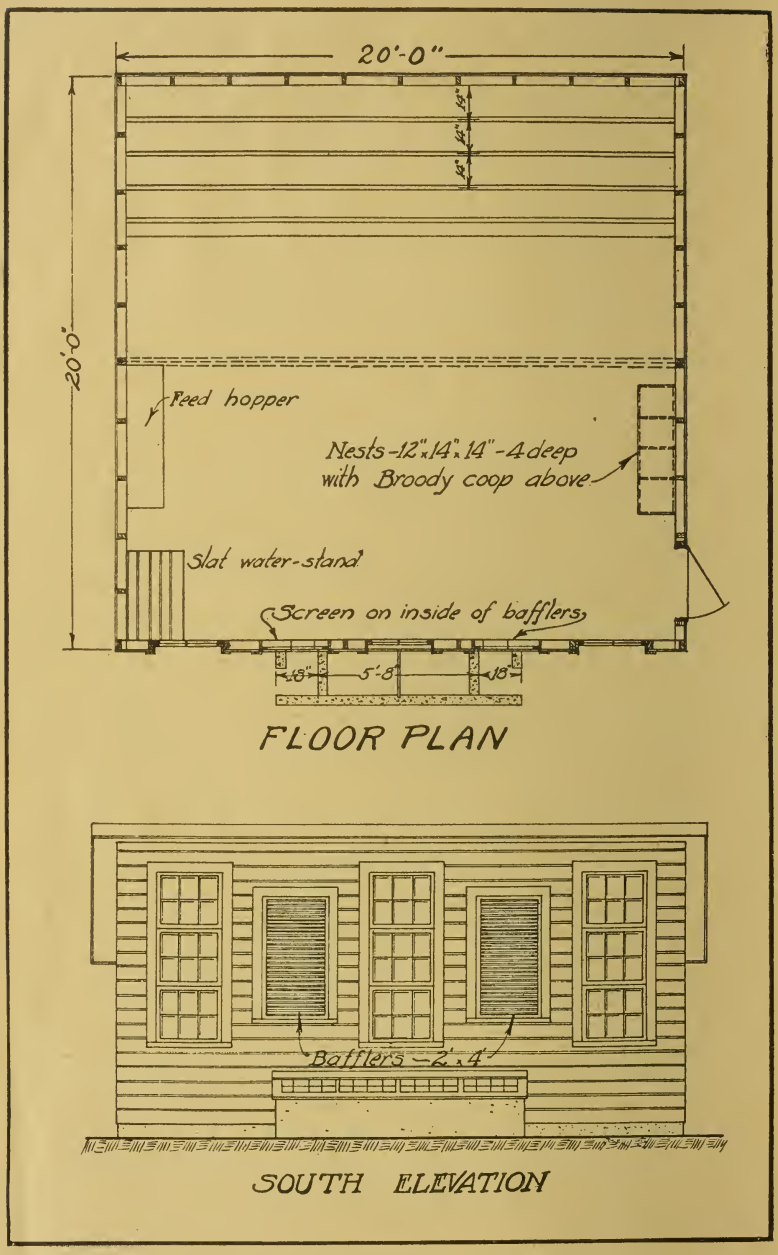

FIG. 17B.—ELEVATION AND FLOOR

A good plan for a 100-unit house

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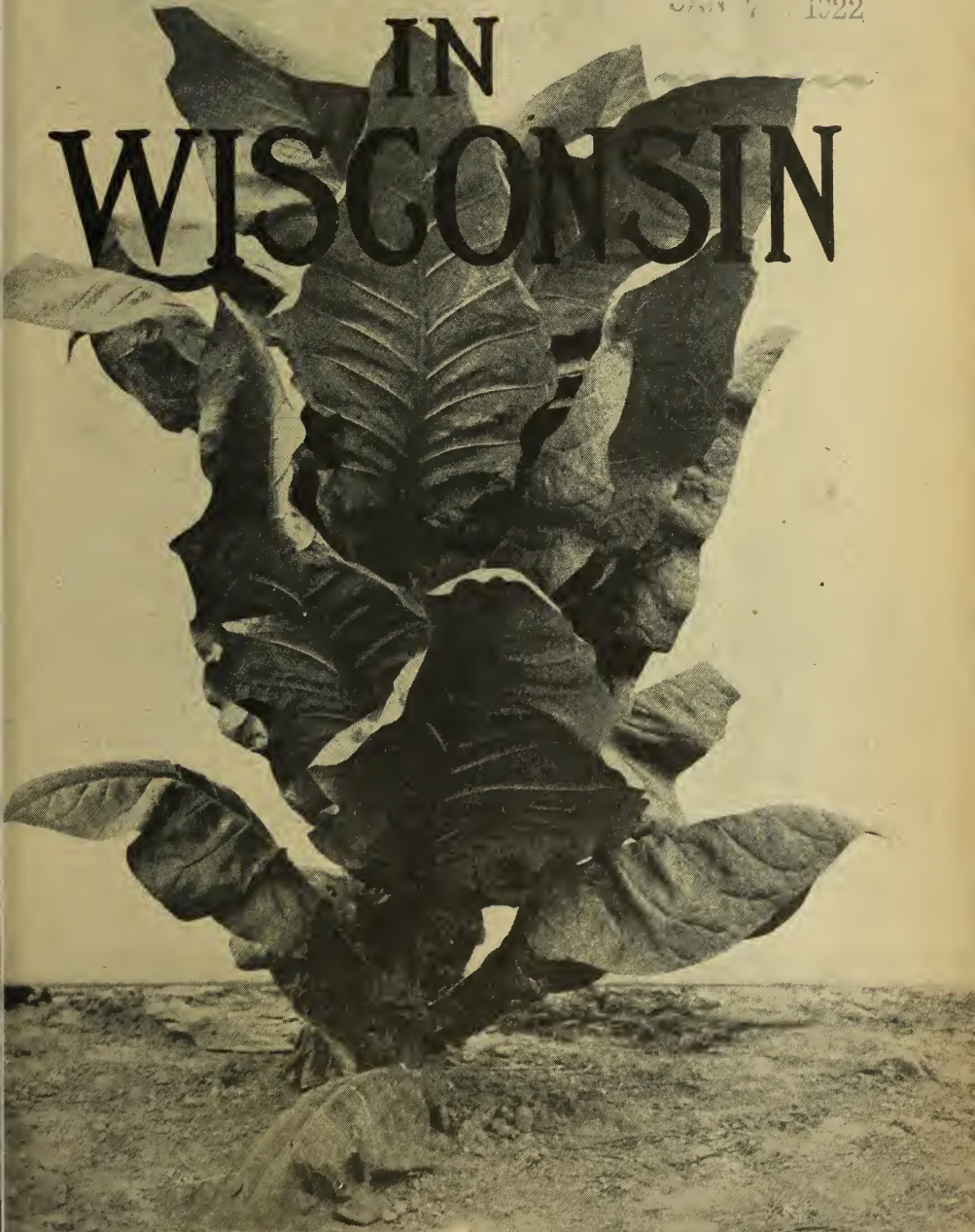

AGRICULTURAL EXPERIMENT STATION
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MADISON

DIGEST

The Havana seed or Spanish type is best suited to Wisconsin, which is known in the tobacco industry as a cigar-binder growing district. Page 5.

The best quality of tobacco is grown on the sandy loam or prairie loam soils. The newer soils, free from root-rot, ordinarily give the best yields. Page 7.

Rotation and the use of resistant strains help to control root rot. Pages 10, 17.

Steaming the seed beds makes plant growing easy. Page 14.

Sowing the seed too thickly in the seed beds is the most common fault among Wisconsin growers. Page 15.

More commercial fertilizers can be used with profit by Wisconsin growers on their new tobacco fields. Fertilizers are often wasted, however, on tobacco-sick soils. Page 18.

Late planting is often more desirable if tobacco must be planted on the old fields. Page 20.

On new tobacco land, early planting usually gives the best results in yield and in quality. Page 20.

The essentials for successful curing are: Favorable weather conditions, a properly built shed and an understanding of how to manage the process. The early crops are most likely to benefit from favorable weather conditions. Page 28.

Neatness and uniformity of the bundles and careful attention to grading will increase the value of the crop when it is put on the market. Page 32.

Tobacco in Wisconsin

James Johnson and C. M. Slagg

The tobacco crop is one of the six crops standing highest in farm value in Wisconsin, and is exceeded only by potatoes as a "special" or "cash" crop. A twenty-year average for this state in round numbers shows an acreage of 43,000, a production of 52,000,000 pounds with a value of over $6,000,000. High prices occasioned by war conditions brought the value of the 1918 crop up close to $20,000,000 and stimulated production but prices and acreage are again approaching normal.

Yield and Profits

The acre yield may normally vary between 1,000 and 2,000 pounds of cured leaf. The average yield for the state in any one year, however, is said to vary from 900 pounds in poor years like 1915 to 1,400 pounds in good years, for instance 1900 or 1916. The average over a period of years is about 1,250 pounds.

The price per pound has varied widely the last few years owing to abnormal conditions. Prices of from 7 to 42 cents were, in fact, reported for the 1920 crop. Normally, a range of from 10 to 20 cents a pound may be expected as representing the variation in market value of the leaf on the farm. The average price paid for the Wisconsin crop over a twenty-year period is between 11 and 12 cents.

The returns per acre will ordinarily range between $125 and $250. The actual profit naturally will vary greatly owing to annual and individual differences in cost of production. A good crop should bring on the average, however, a net profit of about $100 per acre in return for the risk involved and the managerial responsibility carried.

Cost of Production

The actual cost of production, based on interest on investment in land, curing shed, tools and other equipment, fertilizers and supplies, horse work, and labor has been variously estimated at

from $50 to $100 an acre under ordinary conditions. The cost of the 1918-1920 crops were, of course, relatively higher. But the experienced grower who uses good judgment can increase his profits by lowering cost of production. To do this, however, the grower must consider the cost per pound rather than the cost per acre and this may sometimes involve increased rather than retrenched expenditures on the acre basis.

TABLE 1.—ACREAGE OF LEADING WISCONSIN TOBACCO COUNTIES, 1920.

County	Acreage	County	Acreage
Dane	19,980	Trempealeau	1,042
Vernon	9,539	Jackson	732
Rock	7,705	Jefferson	617
Columbia	3,299	Dunn	603
Crawford	2,449	Other counties	2,884
Monroe	1,218		
		Total	50,068

TABLE 2.—AVERAGE ANNUAL ACREAGE, PRODUCTION AND VALUE OF TOBACCO IN WISCONSIN BY DECADES, 1860-1920.

Decade	Acreage	Production pounds	Average farm value
1860-1870	391	312,800	$ 46,294
1870-1880	4,125	4,079,625	330,450
1880-1890	16,227	15,464,331	1,623,754
1890-1900	26,988	30,010,656	2,280,809
1900-1910	40,280	48,779,080	4,195,000
1910-1920	45,225	53,229,885	8,410,312

EQUIPMENT NECESSARY

In addition to horses, wagons, plow, disc, harrow, and cultivators the tobacco grower needs considerable special equipment of which the curing shed is the most expensive. Tobacco lath, transplanting machine, seed-bed frames and sheeting or canvas covers, tobacco axes, spears, hauling rack, packing box, packing paper and twine, and other minor equipment is necessary. The best growers are continually selecting and improving the equipment, and keeping it in proper repair, thereby helping to reduce the cost of production.

SKILLED LABOR

Skilled labor is the most essential asset where a considerable acreage is grown. Such labor is especially valuable during the planting and harvesting season where speed and care are required

in handling the crop. Experienced labor is usually worth a considerably higher wage than inexperienced labor. Where a large acreage of tobacco is handled, however, considerable unskilled labor may be used with advantage at a lower wage.

FIG. 1.—A DESIRABLE TYPE

This type, Connecticut Havana No. 38, developed by the Wisconsin Experiment Station, illustrates many of the desirable points of form or habit of growth for Wisconsin tobacco. (Compare with Fig. 2.)

TYPE OF TOBACCO GROWN

Fully ten or twelve different types (distinct varieties) of tobacco are grown in the United States in as many, or more, districts or sections. These tobaccos are used by the trade for different purposes. There is a distinct localization or specialization, therefore, in regard to the type grown in each district; and the

prices of cured leaf depend largely upon the relative supply and demand and upon the quality of the type produced in each section. For this reason, efforts to market new types in a section, or to market tobacco outside the regular growing sections usually result in failure.

FIG. 2.—AN UNDESIRABLE TYPE

Though this type has a fairly good leaf it is undesirable on account of its habit of growth. The leaves are too far apart and have a tendency to droop.

The Wisconsin tobacco district is recognized as a cigar-binder growing region because the varieties grown and the quality produced are satisfactory for that purpose. Cigar-binder tobacco must be relatively sound and of good and uniform quality, but a large part of the leaf produced in Wisconsin is not suitable for that purpose, so that there is still a large opportunity for general improvement of the grade of tobacco produced in this state.

GROWING AREAS

The tobacco sections in Wisconsin are usually classified by the trade as "southern" and "northern". The southern area lies principally in Dane, Rock and Columbia Counties. The northern area lies principally in Vernon and Crawford Counties, but also

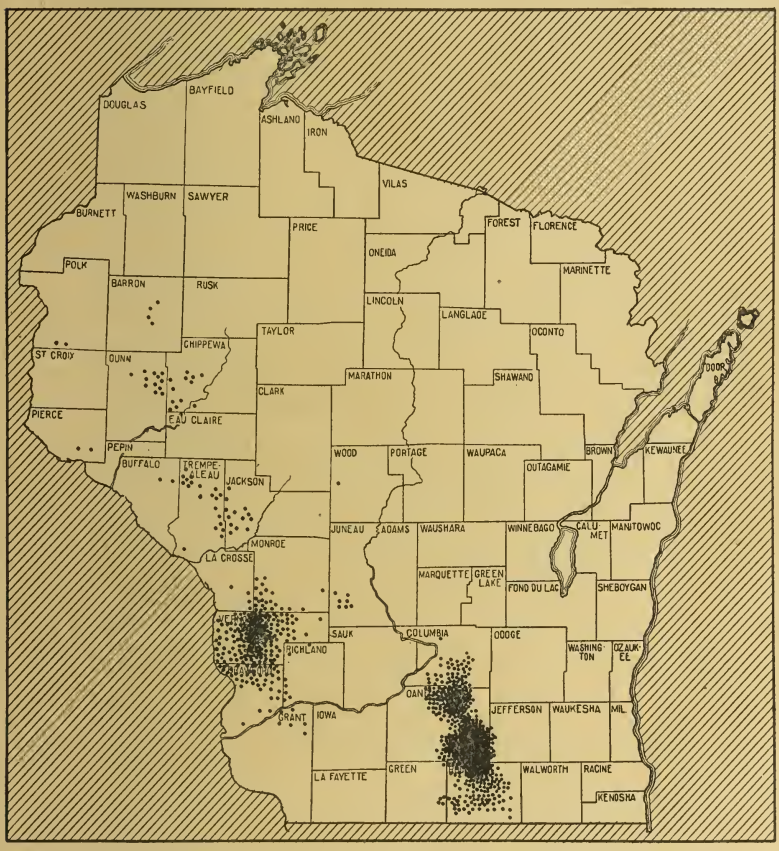

FIG. 3.—WISCONSIN GROWS 50,000 ACRES OF TOBACCO
This map shows the leading tobacco areas in Wisconsin. Each dot represents 50 acres of tobacco.

includes parts of the bordering counties and two smaller areas north of this primarily in Trempealeau and Chippewa Counties.

THE BEST SOILS

The finest quality of tobacco is usually grown on the sandy loam soils of Wisconsin, when adequately fertilized. Such soils are quite typical of Vernon and Crawford Counties. In the

"southern" district, tobacco is grown on light clay loam and on black prairie loams. These soils are usually higher in natural fertility and produce a larger yield per acre, but frequently a higher percentage of darker and heavier leaf. New soils of this type, however, or soils properly managed so as to keep up the vegetable matter, produce tobacco of very desirable quality.

The growing of tobacco should not be attempted upon heavy clays, or on muck or peat soils because they will not ordinarily produce a good quality of leaf.

WHAT IS QUALITY?

Quality in tobacco is frequently an indefinite and sometimes an obscure term. Its meaning varies with different manufacturers and with different types of tobacco, and sometimes changes as the "fashion" of the types desired change. Generally speaking, a cigar-binder leaf should have the desirable qualities of a cigar wrapper leaf but does not need them in so marked a degree.

First, of course, the leaf must be *sound* and have *sufficient size* to permit the cutting of at least one binder from each side of the leaf. It is very important that the leaf have good *"burn"*, but this is usually taken for granted with Wisconsin tobacco if the general appearance is desirable. The *color* of the leaf (including uniformity of color), the *texture* (grain and relative coarseness of the leaf structure) and the *body* or thickness of the leaf, are of primary importance. The size of the veins, elasticity, flavor, aroma. and style are also to be considered.

The buyers of binder leaf ordinarily prefer a medium-sized leaf (22-24 inches long) of a light brown uniform color, close grained, of medium body, and good elasticity.

TOBACCO SEED

A number of so-called varieties of tobacco are grown commercially in Wisconsin. Many of these, although under different names, are practically identical and make up what properly may be called the Havana Seed or Spanish type. In some cases fairly marked differences in yield and appearance of the plants are observable, and in other cases the variety name has been so well established as to warrant its continued use. Of the Havana seed types, the Connecticut Havana, Comstock Spanish and Connecti-

cut Havana No. 38 varieties are regarded as standard for this type.

Another group of varieties which is usually classed as "Big-Seed" are grown, but the classification of these is not in all cases

FIG. 4.—BAGGING THE SEED HEAD PREVENTS CROSSING
Where two or more strains of tobacco are grown close together this method is effective.

distinct, and varieties which cannot be classed in either of these types can be found. "Big-Seed" types usually have a larger leaf,

and take on a more distinct drooping habit of growth than the Havana Seed types. On the whole they are not considered so desirable for binder purposes as Havana Seed although they usually give a larger yield per acre. This has been found in many cases to be due as much to greater resistance to root-rot* as to an in-

FIG. 5.—PRODUCING SEED FOR FARMERS
A seed plot at the Experiment Station in which half of the plants have been selected for seed and bagged.

herent power to give greater yield. Consequently, on new ground free from root-rot there is really no good reason for growing these types.

The Wisconsin Experiment Station in recent years has attempted to obtain a strain of tobacco, with a habit of growth and quality similar to Havana Seed but with marked resistance to root rot. It has not as yet entirely succeeded, but a strain distributed by the Experiment Station as "Resistant Cigar Binder Seed" has been widely grown and on the whole very favorably received. Further improvement along this line is anticipated.

PURCHASING SEED

Several tobacco growers and dealers in Wisconsin grow and sell tobacco seed. Such seed is reliable in most instances as to variety name and germinating capacity. Growers who sell seed only occasionally may not always furnish a product so reliable as to variety name or germination. A large amount of seed is exchanged and sold, of course, between individuals personally

*See other Wisconsin Experiment Station bulletins on tobacco.

acquainted, or through recommendations from buyers. Tobacco seed is a very small expense in connection with growing the crop, since it usually sells for 50 cents an ounce, an amount sufficient for from two to four acres.

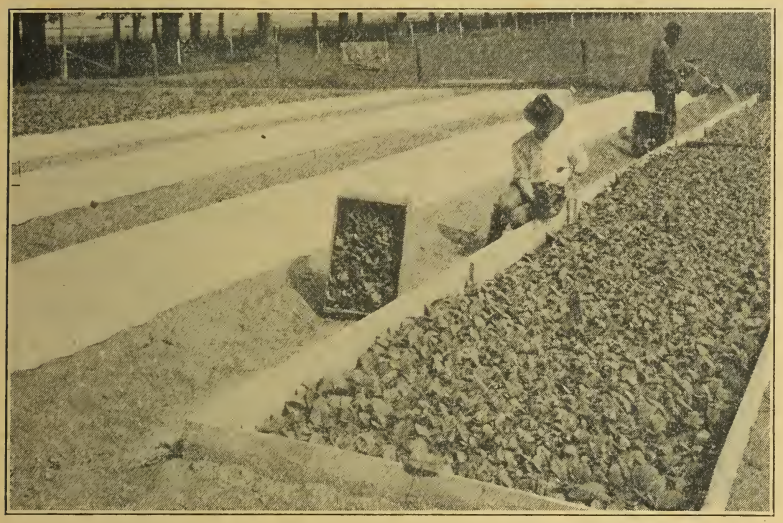

FIG. 6.—GOOD PLANT BEDS ARE IMPORTANT

To secure plenty of strong, healthy plants on time use good seed, steam the soil, sow the seed thinly and do not let the beds dry out when the plants are young.

SELECTING SEED

Many growers select their own seed, a good practice when a desirable type has been obtained. Where more than one strain of tobacco is grown in close proximity, however, mixing is likely to result due to crossing through the flowers. This can be prevented by "bagging" the seed heads. This is done by inverting a twelve-pound size manila paper bag over the flower head as soon as it is strong enough to support the bag. First remove all open flowers or pods which may have formed. The seed plants saved should be of uniform type; and if plants are saved which are thought to be of different strains, the seed should be saved separately. If a "pure strain" of seed is being used, variation should not occur and the likelihood of any improvement being made by selection is very small. Careful attention to selection will help to keep the seed up to the original standard by eliminating any undesirable types which may creep in.

CARE OF SEED PODS

When the seed pods are practically all ripe they can be picked off or the entire seed head cut off. The seed heads or pods should be stored in a dry place in order to dry out thoroughly before being threshed. It is important to store them in such a way that mice cannot get at them, since they feed very greedily on tobacco seed.

SEED CLEANING

Tobacco seed is usually threshed out of the pods by hand and separated from the pods and chaff by screening. The dust, small chaff and light seed may be blown out by means of an air current. The Wisconsin Experiment Station has developed a special machine for this purpose which permits large quantities of seed to be uniformly cleaned with fair rapidity. This seed cleaning device has been available to seed growers for several years; and hundreds of pounds of seed are cleaned annually. This method eliminates the light poor seed and raises the germination percentage.

SEED TESTING

Much uncertainty and difficulty can be avoided by testing tobacco seed previous to sowing. The germination of tobacco seed varies greatly with the conditions under which it is grown and ranges commonly between 50 and 100 per cent. The growers' uncertainty as to the germinating power of the seed is a common reason for thick sowing, which is one of the most serious drawbacks to the production of good plants in Wisconsin. When buying seed, insist on having its germinating test; and test your own seed or send it to the Wisconsin Experiment Station to be tested for you. A simple way to test tobacco seed is to place a moistened—not too wet—blotter or felt cloth on a dinner plate. Take a small sample, preferably 100 seeds, and scatter them over this moist surface; then cover with a pane of glass or dish and set the plate away in a place a little above room temperature, (about 75-80° F.). Wet the blotter occasionally if needed so the seeds will not dry out. It is well to start two or three tests at a time to provide a check on results. After five to ten days all the living seeds should have sprouted and the percentage of germination may be found.

Sprouting Seed for Sowing

Practically all tobacco seed in Wisconsin is sprouted indoors before sowing. This is usually done in one of two ways: (1) by mixing the seed with moist, finely ground, rotted wood (punk) or sawdust or (2) by keeping the pure seed moist but not wet between heavy cloth. The sprouting seed is usually kept at ordinary room temperature and should not be kept too hot. If the seed is germinating too fast it can be held back by placing it in a cooler room. The seed should be stirred occasionally to allow air to get into it and to permit uniform sprouting.

Sowing Dry Seed

In most tobacco districts outside Wisconsin, tobacco seed is sown in the dry or unsprouted condition. This has some distinct advantages, one being that the seed can be sowed at any time that the seed beds are ready. Tobacco seed is frequently spoiled in the sprouting process indoors due to unfavorable conditions, whereas under normal seed bed conditions the seed will merely remain dormant until weather conditions are favorable for germination. Sprouted seed will have a few days start on the unsprouted seed in the seed beds, although this advantage almost disappears toward transplanting time. At the Wisconsin Experiment Station only dry seed has been sown for the last six or seven years with good success. For the present we recommend sowing dry seed on sterilized beds if the sowing is done before April 25. For unsterilized beds, or for later sowing, sprouted seed may have some advantages, in getting a start on the weeds and in producing earlier plants.

THE SEED BEDS

The seed beds should be located in a sunny and warm place, preferably on a southern slope or where otherwise protected on the north. The soil should be loose and not have a tendency to bake. A very fertile soil is desirable—either sandy or else liberally supplied with vegetable matter. On account of the danger from root rot, avoid using an old tobacco field for seed beds. If the soil is not to be steamed, avoid places which are likely to be very weedy. Pasture sod properly handled makes good seed beds and is less weedy. If possible the beds should be located

convenient to a water supply. It is also advantageous to change the location of the seed beds every two or three years even if they are steamed to reduce danger from root rot.

PREPARING THE SEED BEDS

Wisconsin tobacco growers could ordinarily use more well-rotted manure on their seed beds than they are now doing. This would loosen the soil and increase the fertility. Manure applied in the fall and plowed under, followed by another spring application before plowing, may be used with profit. If commercial fertilizers are used they should be applied as a top dressing before the final preparation of the soil. About 5-10 pounds of a complete fertilizer can be used for each 100 square feet. Nitrate of soda, if needed, can best be applied in solution after the plants are up. The soil should be worked into a fine tilth. The beds should be slightly higher in the middle than at the sides and as smooth as possible. If the beds are to be steamed it should be done after the soil is practically fitted for sowing.

SEED BED FRAMES

The tobacco bed frames are usually a little less than 6 feet wide, and are made of 16-foot boards 6 or 8 inches wide, over which the tobacco bed sheeting or "canvas" is stretched. This is preferably held up in the center by a galvanized iron wire running lengthwise of the bed about two or three inches above the level of the frame boards. Many growers prepare a permanent frame, 12 to 16 feet long and six feet wide; and the entire frame is removed when it is desirable to remove the covering. These have the advantage of always being ready but require more lumber and more room for storage. Some growers use covers without frames and others do not use covers at all. These methods are not recommended for growers who have not had experience in growing plants in this way.

STEAMING THE SEED BEDS

It is now well recognized in Wisconsin that steaming tobacco beds is profitable and also an assurance that good plants will be produced. The main advantages of steaming are that the weed

seeds are killed, seed bed diseases are checked and earlier and more vigorous plants are produced.* The seed can be sown as soon as the soil is cooled or the soil can be steamed several weeks previous to sowing——the latter is preferable in some respects.

TIME OF SOWING THE SEED

In Wisconsin the seed is usually sown between April 15 and May 1, although on steamed beds seed may be sown as late as May 7 with fair certainty of having plants for transplanting by June 20 to 30.

METHODS OF SOWING

Where seed is sprouted in rotted wood or sawdust it is sufficiently diluted with this material to be sown as soon as it is sprouted and the beds are ready. When the pure seed is sprouted it is usually sown (when just showing the sprouts) with water in a sprinkling can. The holes in the rose should be large enough to permit the seed to pass through and the seed should be kept suspended in the water by frequent stirring or shaking. This method when properly followed permits of quite uniform sowing. Unsprouted seed can be sown in the same way or by diluting it with meal, ashes, lime, or similar material. The seed should be raked in lightly after sowing, and in some cases the soil is packed with a roller or with a board although this is usually not necessary where the beds are watered regularly.

THICKNESS OF SOWING

The most common mistake made in sowing seed beds in Wisconsin is too thick sowing. One ounce contains about 350,000 seeds, which would furnish enough plants for from 35 to 50 acres of tobacco if they all grew vigorously and it were possible to use every plant. Too thick sowing tends to produce spindly and weak plants, and seed bed diseases are more likely to be prevalent. Many Wisconsin growers sow one ounce of seed on two to four rods of bed six feet wide (about 200-400 square feet). Better results would be secured by using this amount of seed on six to eight rods of bed, or even on eight to ten rods of bed where the seed is known to germinate above 90 per cent and where steamed soil is used.

*See other Wisconsin Experiment Station bulletins on tobacco.

WATERING

It is important to watch the beds daily during dry weather when the plants are very small, since severe drying (which is more likely to occur on steamed than on unsteamed soil) is likely to kill out a number of the seedlings. After the plants are fairly well rooted, drying even to the stage of slight wilting may do no injury. At this time watering should be thorough rather than frequent, which will favor the development of a good root system.

USE OF NITRATE OF SODA

Where tobacco plants are making a slow growth, or show a tendency to yellow in the seed bed, they can ordinarily be improved by drenching the soil with nitrate of soda solution, at the rate of 2 to 3 pounds of the nitrate to one barrel (50 gallons) of water. This solution should be liberally applied so as to get down into the soil for two or more inches. It is advisable to sprinkle lightly with pure water following the application. This washes the solution off the leaves. Two applications a few days apart will usually be sufficient.

DISEASES AND INSECTS

Bed-rot, or damping-off, and root-rot sometimes cause considerable injury in the seed beds. Occasionally fleas cause some damage. Soil steaming or the use of soil free from these troubles are the only effective and practical ways of prevention. Drying the beds will help to check bed-rot; and air-slaked lime is sometimes used to discourage the fleas.*

HARDENING-OFF THE PLANTS

Tobacco plants grown under cloth are quite tender, are more likely to be broken in pulling or in transplanting, and are also in more danger of being burned by the sun if transplanted on a hot, dry day than are plants accustomed to full sunlight. For this reason it is a good plan to remove the covers, at least during the day time, for a few days before transplanting in order to "harden-off" the plants. If the plants are growing too rapidly and the fields

*See other Wisconsin Experiment Station bulletins on tobacco.

are not ready for transplanting the cloth can be left off permanently after about June 1, although it is a good plan to replace it when heavy storms are likely to occur.

Pulling the Plants

Tobacco plants should preferably be pulled on the same day they are set although they will keep fairly well for two or three days if pulled with dry leaves and stored in an upright position in a cool place.

Water the beds thoroughly some time previous to pulling so that the soil adhering to the roots will not be sticky and interfere with dropping the plants on the machine. The plants should preferably be pulled from the soil by grasping the leaves. Permanent injury may be done to the stem by pressing it too tightly between the fingers in pulling. Plants showing signs of disease on the leaves, stems or roots should preferably be discarded as should all small spindly plants and those excessively large. Plants uniform in size, with a medium long, straight stem, a fair-sized root system and detached from other plants are best for good setting by machine. Two or more pullings can be made from each bed, but the third and succeeding pullings are likely to yield crooked and inferior plants.

MANAGEMENT OF THE FIELD

The main points to consider in selecting the soil for the tobacco field are its adaptability to the tobacco plant, its natural fertility, and its freedom from the root-rot disease. The best tobacco soils are relatively loose, containing considerable sand and humus, and have good drainage. The soil must be fairly fertile and if it is not, liberal applications of manure or commercial fertilizers should be used. Soils which have grown three or more crops of tobacco are likely to have considerable root-rot in them, and unless disease resistant varieties are grown it is usually preferable to grow the crop on new tobacco ground with less fertility than to take chances on more fertile "tobacco sick" soils.

Crop Rotation with Tobacco

Tobacco growers are coming more and more to use a regular system of rotation for their tobacco fields. This helps to control

root-rot in addition to its other advantages. A model rotation in Wisconsin would be to grow tobacco three years in succession on the one field. On the other "tobacco field" during this time grow a crop of corn followed by barley and clover. On some soils a four-year rotation—sowing timothy with clover—would probably be more satisfactory. The fourth year would then produce a crop of clover and timothy—the second crop of which preferably should be plowed under in the late fall. Oats may be substituted for barley on poorer soils, though there is much danger of considerable lodging in wet seasons.

FERTILIZING THE TOBACCO FIELD

Barnyard manure, at the rate of about twenty tons to the acre, is commonly applied to tobacco fields in Wisconsin. In order to give results with the succeeding crop this should preferably be applied in the fall, or be well rotted if applied in the spring.

Commercial fertilizers can profitably be used alone or in conjunction with barnyard manure on most Wisconsin tobacco soils. Most of our tobacco soils respond to fertilization with phosphate fertilizers; and this element can profitably be applied alone or in combination with barnyard manure at the rate of 400-800 pounds per acre in the form of acid phosphate. On soils relatively low in fertility it is safest to apply a complete fertilizer—that is, one containing nitrogen, phosphorous and potassium in the proportion of 2-12-2, or a similar formula.*

PREPARING THE FIELD FOR PLANTING

The preparation of the tobacco soils should be such as is most conducive to perfect tilth, retention of moisture, and destruction of weeds and insect larvae. Fall plowing should be practiced where possible on sod lands. Late spring plowing has some disadvantages, and in seasons of drought is often a serious handicap to the crop. Tobacco soils most frequently receive no cultivation whatever during ten months of the year. The soil, being devoid of any mulch for that length of time, is in a favorable condition for the loss of water, which could be retained in part for the use of the crop. Working the land early in the spring and keeping a mulch on the surface until planting time will materially aid in

*See other Wisconsin Experiment Station bulletins on tobacco.

conserving soil moisture and in helping the plants to make a good start, even if rain does not fall until two or three weeks after setting.

The early preparation of the land will also be found to control the major portion of the weeds as they will start early and can

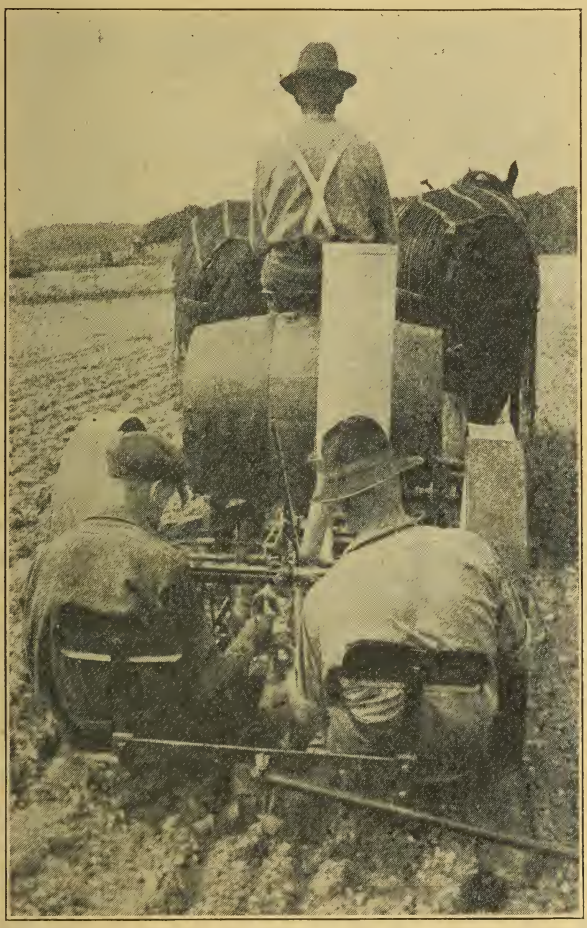

FIG. 7.—CARE IN TRANSPLANTING PAYS

The essentials for success with the transplanting machine are: Good tilth of the soil, clean plow and packers on the machine, two careful droppers, and good plants carefully picked from the seed beds.

be killed much more readily before than after setting the plants. Good tilth is very important in securing a good and uniform stand of tobacco, and to this end the disk, drag, and planker must be used at the proper time.

A practice which should be discouraged among growers is that of leaving the ground rolled or planked for any length of time. This condition aids the rapid escape of moisture. The roller or planker is used to compact the soil and bring it into fine tilth, but should be followed by a light harrowing.

TRANSPLANTING INTO THE FIELD

Transplanting is done in Wisconsin between June 1 and July 8. Usually neither the early nor the late settings give the best results. No fixed time can be recommended as this varies with the year, and the time the plants are ready for transplanting. June 10 to June 25, however, is usually conceded to bring the most favorable results. The plants are set with a transplanting machine. With two good "droppers" the plants can be set very much more satisfactorily than by hand planting. During hot, dry weather, planting should preferably be done only in the afternoon as the plants are liable to "burn out". Other essentials for hot weather planting are to have plants well "hardened-off" to the sun, stocky in form, and set well up to the bud. A spindly plant set with a portion of the stem above the ground will wilt rapidly, and cause the previously shaded stem to become fully exposed to the sun's rays. The injury resulting to the stem will usually kill the plant whereas the burning of the leaves will only check its growth.

The planting distance in Wisconsin varies from 32 to 38 inches between the rows, and 18 to 24 inches in the row. The closeness of planting should be determined largely by the fertility of the soil and the type of tobacco grown. "Big Seed" types on fertile soil are very difficult to work and frequently become very ragged unless the plants are set even greater distances apart than those mentioned. On the other hand, close planting tends to produce a leaf of better texture and color. It is partly for this reason that the Havana types of tobacco give the most satisfactory quality, while the closer planting enables practically as large yields to be obtained.

PLANT OLD FIELDS LAST

Old tobacco fields harbor the most root-rot. This disease is most serious in cool seasons or in the cooler part of the season, as for instance in June and early July. By transplanting old fields late the crop may not get badly stunted before the warmer weather

of July and August, when the disease may be checked. Consequently it is advisable where possible to make the first planting on the newer tobacco soils where root-rot may not be present, saving the old fields for as late planting as is possible and consistent with the time required for the crop to mature properly.

FIG. 8.—A GOOD TOOL FOR REPLANTING
With a blade-like "dibber" such as this replanting can be done when the soil is relatively dry. Select strong plants with some moist soil attached to the roots. Kick away the dry surface soil and set the plant firmly with the dibber. A good size for dibber blade is 2x6 inches.

REPLANTING

It is practically always necessary to replant a field by hand in order to get a good stand due to cutworm injury, burning out, or other damage. This is best done one or two weeks after planting. If the soil is in good tilth it is usually not necessary to wait for a rain in order to do this. A good dibber can be made by grinding down a large file or steel bar and attaching a knob at the end

(Fig. 8). With this, transplanting can be done in relatively dry soil without hand watering if plants with good roots are used. The advantage of this form of transplanting tool is that it can be used with ease in a relatively compact soil. It gives a good opening for inserting the roots without crowding and permits the dirt

FIG. 9.—THIS FIELD HAS HAD A GOOD START

The young tobacco crop needs frequent cultivation to conserve the soil moisture for the critical period in July when dry weather is likely to occur.

to be pressed tightly against the roots without materially disturbing the tilth of the soil. In this way replanting can be done a week to ten days after a rain without watering out.

CULTIVATE FREQUENTLY

The cultivation of tobacco does not differ materially from that of other farm crops. The grower should always keep in mind the chief object of cultivation,—that of conserving the soil moisture, which evaporates much more rapidly from the soil when not protected by a mulch. Ordinarily, therefore, it is a good plan to cultivate as soon as possible after a rain in order to save the moisture for possible periods of dry weather which usually come during July. The one-horse, drag-tooth, lever adjustable cultivator is preferable for the early cultivations. Some growers use the two-horse sulky cultivator as the tobacco grows larger; and if the cultivator is skillfully handled good work can be done with it.

Weeds should not be allowed to get such a start that deep cultivation is necessary. Hand hoeing is usually necessary and advisable. The "horse-hoe" or weeder may replace it on light soils quite free from weeds.

FIG. 10.—THE TOPPING STAGE OF GROWTH
Topping can be best done when the flower heads are about this stage. Some growers prefer to top earlier.

DISEASES AND INSECTS IN THE FIELD

Ordinarily the most troublesome insect pests in the field are cutworms, the tobacco worm, and grasshoppers. The most ser-

ious disease in the field in Wisconsin is root-rot. Mosaic, frenching, leaf spots (rust) and other minor troubles may occur, but this subject is too large to be adequately treated in this bulletin.*

TOPPING

When the flower heads have lengthened sufficiently to expose all the leaves separately, the tops should be broken off, usually

FIG. 11.—READY FOR HARVEST
Tobacco is ready for harvesting when it has been topped about three weeks and suckered.

about one leaf below the lowest "bald" sucker (a sucker without leaves). The practice as to time and height of topping varies considerably among growers, but as a general thing it is not good practice to go to either extreme. Ordinarily the best time to remove the top is when the first blossom buds open. The exact height at which to break off the top varies with the size and vigor of the plant.

SUCKERING

The suckers grow rapidly after topping and must be broken off before harvesting. One suckering only is ordinarily practiced in Wisconsin, although going over the field twice may often be advisable. This involves considerably more labor since the removal

*See other Wisconsin Experiment Station bulletins on tobacco.

of the top suckers stimulates the growth of the lower ones. On the other hand, large top suckers become woody and are broken only with difficulty. Much suckering is done just previous to harvesting, but in general it is best to sucker the plants two or three days ahead.

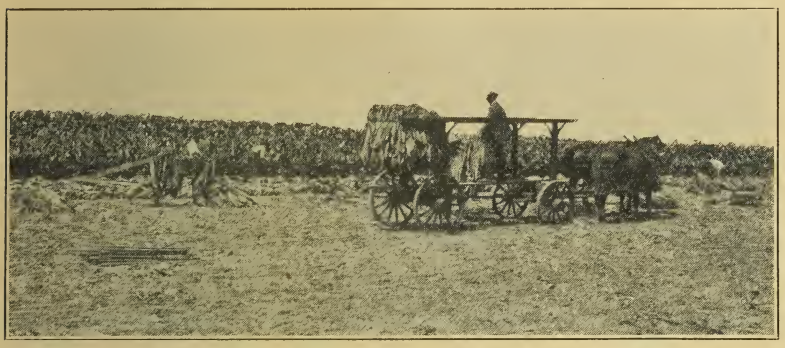

FIG. 12.—THE GROWER'S BUSY SEASON
A gang of five men can work together efficiently in harvesting. They often harvest an acre a day.

RIPENING

The tobacco is usually harvested two to three weeks after topping. It is difficult for an inexperienced person to determine just when the crop is sufficiently ripe for cutting. The only change is that the leaves take on a slight yellow tinge in spots in place of the normal uniform dark green color. The bottom leaves ripen first, consequently it is impossible to get leaves uniformly ripe where the entire plant is harvested at one time. Tobacco harvested when slightly green is more likely to give a thinner leaf of finer quality than that harvested over-ripe, under good curing conditions. Late tobacco harvested too green followed by poor curing conditions is, however, not likely to yield good quality.

HARVESTING THE CROP

The tobacco harvesting season is usually a very busy one and skilled labor is high priced. The grower should have all the necessary tools, equipment, and sheds in good repair and the necessary help arranged for beforehand so that no time need be lost on these details.

CUTTING

The plants are cut with a small hand ax, close to the ground.

The butts are preferably laid toward the sun on a hot day. Ordinarily each man cuts only one row laying the plants down on the row. In other cases each man may cut two rows at a time laying the plants together. The best time to cut is in the morning after the dew has left the plants, and not later than three or possibly four o'clock on a warm sunny day. Unless necessary, it is not a good plan to cut down more than can be hauled in each day.

FIG. 13.—STRINGING OR "SPUDDING" TOBACCO

To string tobacco rapidly and carefully requires experience and skill. A good worker can string from one-half to one acre a day depending on the condition of the tobacco.

WILTING

The plants must wilt sufficiently so that they can be handled readily without breaking the leaves off the stalk. Care must be taken at midday in hot weather not to allow the wilting leaves to become sun-burned, since this causes permanent damage to the leaf. On hot, dry days the plants may need to be piled one hour after cutting. Tobacco allowed to wilt too much before piling makes a poor appearance in the shed and is more likely to damage in curing.

PILING

As soon as the plants are sufficiently wilted, put them in medium sized piles, butts preferably toward the sun. When there is not much danger from burning, the tops of the plants can be spread out wide in the pile bringing the butts close together in a narrow

vertical line, thereby aiding in the rapidity with which the stringing can be done. The tobacco may heat and become damaged in the piles if left for more than twenty-four hours.

FIG. 14.—A GOOD RACK IS HELPFUL
Such a rack as this reduces to a minimum the danger of injuring the leaf in handling. A load of tobacco carries anywhere from 80 to 120 lath, depending upon how well the plants are wilted.

STRINGING

Five to seven plants of ordinary size are usually placed on each lath. More skill is required in this operation, in order to do it well and quickly than in any other harvesting work. Most of the tobacco is strung with a stringing "horse" or "jack" (Fig. 13) although some workers prefer to string the plant with one end of the lath on the ground. The stringing "horse" is usually made on the farm, and the spear or "spud" can be made by a tinsmith. Twelve to fifteen hundred lath are usually required per acre. Special tobacco lath are best as ordinary building lath are too weak.

SHEDDING

As soon as the tobacco plants are strung they can be hauled into the shed. All Wisconsin growers use the standard tobacco rack (Fig. 14) which is usually 12 to 16 feet long. The laths are hung five to eight inches apart on the hangers in the shed depending on the size of the tobacco. Too close hanging is conducive to leaf damage in curing, and tobacco hung too far apart is likely to dry out too quickly and result in an inferior cure.

CURING IN THE SHED

The essentials for the proper curing of tobacco are favorable weather conditions, a properly built shed, and a thorough knowledge of the practical principles of managing the curing. A large portion of the poorly cured tobacco produced in Wisconsin can be

FIG. 15.—A DESIRABLE TYPE OF CURING SHED
Curing sheds with horizontal side ventilators and sufficient ventilation at the ridge are considered best.

attributed to the fact that many of the sheds are improperly constructed and others are badly in need of repair. Sheds with leaking roofs and broken ventilators cannot be relied upon to cure tobacco evenly. A model curing barn allows a perfect circulation of air when desired and permits a rapid drying out, but can be closed tightly so as effectively to keep out or retain a moist atmosphere when desired. On the whole, relatively high temperatures and moderately humid weather are most favorable for curing. The rate of curing is much reduced by low temperatures. Very moist weather extending over a considerable period of time is liable to result in damage and the grower must then rely upon his judgment in handling the curing process to prevent damage.

PRINCIPLES OF VENTILATION

To obtain a proper circulation of air it is necessary to have ventilators at the top and bottom of the shed so that the air may pass, as it were, through a large flue. The shed should be built so as to allow a horizontal ventilator to be attached below the sill, extending the full length on both sides of the shed. The roof or ridge ventilator may run along the entire length of the shed or a series of small galvanized iron chimneys containing dampers which can be regulated from the ground by means of ropes may be used. With the ventilators at the top and bottom open, dry air may enter at the bottom of the shed and once inside will absorb

moisture. Moist air is lighter than dry air and therefore will tend to rise. As it rises through the tiers of tobacco it gets warmer and lighter, absorbing more and more moisture, and finally forces itself out through the top ventilators. This system works perfectly when the air outside the shed is dry, but should it become laden with moisture, however, the drying effect naturally

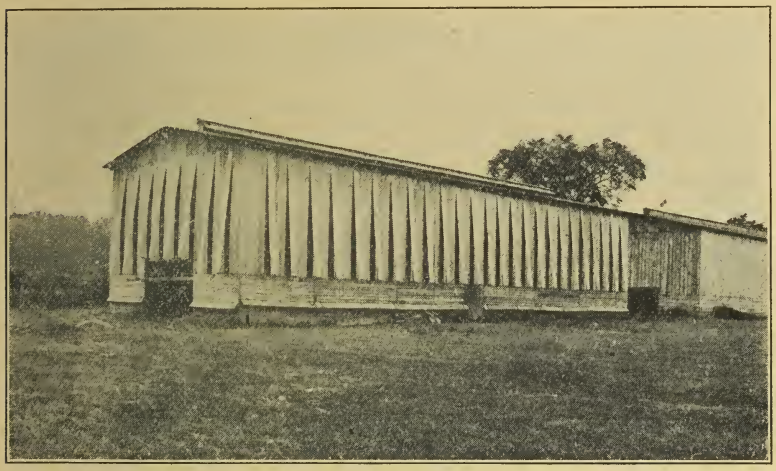

FIG. 16.—THE VERTICAL VENTILATOR SHED
While this type of shed may be built more cheaply it is not as satisfactory nor as convenient as the shed in Fig. 15.

stops, and the shed may be closed up tightly to prevent more moisture getting in. If the weather is moist for a long time at a critical period in curing, it may be necessary to use artificial heat to start circulation and dry off the crop to prevent damage.

In order to produce a rapid change in the temperature and humidity of the shed when desired, it is also necessary to have ventilators, preferably horizontal, just below each tier of tobacco, on both sides of the shed. These are used especially at the beginning of the curing process, and later to bring the leaf into "case" for stripping.

MANAGING THE CURING PROCESS

Exact recommendations for managing the curing cannot be given since this will be largely determined by the weather. The change from the normal green, through the yellow and to the brown color is an expression of a living process in the leaf, and

while the process can be hastened by high temperatures if the humidity is kept up, it should not be hastened by any excessive drying process. Essentially the management of the curing under Wisconsin conditions should be based on the principle that curing is a slow drying process. The operator must go into the shed, feel the leaves and regulate the ventilation according to his judg-

FIG. 17.—STRIPPING FROM THE LATH
Some grading should be done during stripping. Well-made, neat bundles are frequently an aid in marketing the crop.

ment. In general, during the first two weeks the shed should be opened during the day and closed at night. If it starts to cure too rapidly it should be closed up in the daytime and opened at night. Under favorable curing conditions, after a thorough wilt, sufficient circulation may be had by opening only the bottom and ridge ventilators. Some attention must be given until the crop is entirely cured out, which is only when the midribs are well dried out, and the weather has become so cool that there is no danger of damage.

DAMAGE DURING CURING

During extended periods of excessive moisture, especially when the leaf is changing from the yellow to the brown stage, "shed burn" or "pole sweat" is liable to occur. A decay of the midrib, known as stem rot is also likely to appear under similar condi-

tions at a later stage of curing. Too close hanging is of course conducive to such damage. Normally, proper ventilation will check it; otherwise artificial heat is necessary.*

FIG. 18.—PACKING THE LEAF
After the tobacco is assorted it is packed in boxes 28x28 inches and from 36 to 48 inches long. It is then pressed tightly and stored.

PREPARING FOR MARKET

Tobacco is usually harvested between August 20 and September 20. By the latter part of November the crop may be sufficiently cured to be taken down and stripped if brought into "case". Frequently, however, casing weather may not come until January or even March. When it is desired to bring the tobacco into case the ventilators and doors should be opened during rainy or foggy weather until the leaf in the middle and top of the shed is in a pliable condition, but care must be taken not to get any of the leaf in too high "case". Frequently only a portion of the crop comes into case and this may be taken down, permitting later casing weather to get at the remaining leaf more readily. When taken down the laths are stacked closely in large round or rectangular piles with butts out to prevent drying prior to stripping. The stripping of the leaves from the stalks is now usually done while they are still on the lath. The lath is slipped into a slot at the proper height so the plants hang in an inverted vertical position,

*See other Wisconsin Experiment Station bulletins on tobacco.

and both hands are used for picking the leaves. The plants also can be pulled off the lath, piled, and stripped individually.

The more common practice is to strip the "sand-leaves" and ragged leaves from the bottom, tie them up in "hands" and pack separately. Damaged, wet, or other poor grades should also be separated from the good grade of leaf.

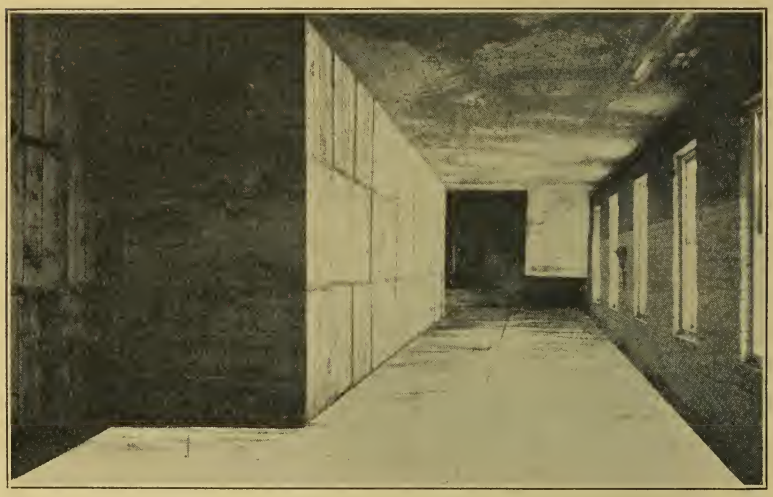

FIG. 19.—THE STORAGE ROOM
Here the leaf passes through the fermentation or sweating process which usually requires several months.

The leaves when stripped should be packed evenly and tightly in packing boxes with the tips overlapping sufficiently to hold the bundle together. Special packing boxes (Fig. 17) of the proper size and furnished with a good press can be purchased on the market. Standard grades of tobacco packing paper and wool twine should be used and the bundles should preferably weigh between forty and fifty pounds.

The bundles can be safely stored in the sheds or other places, where they will not become wet or too dry, in piles about three bundles high until delivered to the warehouses or until April or May. If the tobacco is not sold in the bundle it should be sorted and packed in boxes for long storage.

GOOD HANDLING IMPORTANT

The grower may do as much at stripping time as in any other stage of handling the crop in increasing its market value. Spe-

cial care should be taken not to get the leaf into too high case since this is almost certain to result in damage either in the growers' or packers' hands. High case tobacco should either be bundled separately or hung up again to dry. In addition to this, all damaged or poor grades should be removed. The making of neat, medium-sized bundles, even at the butts, will also aid in getting

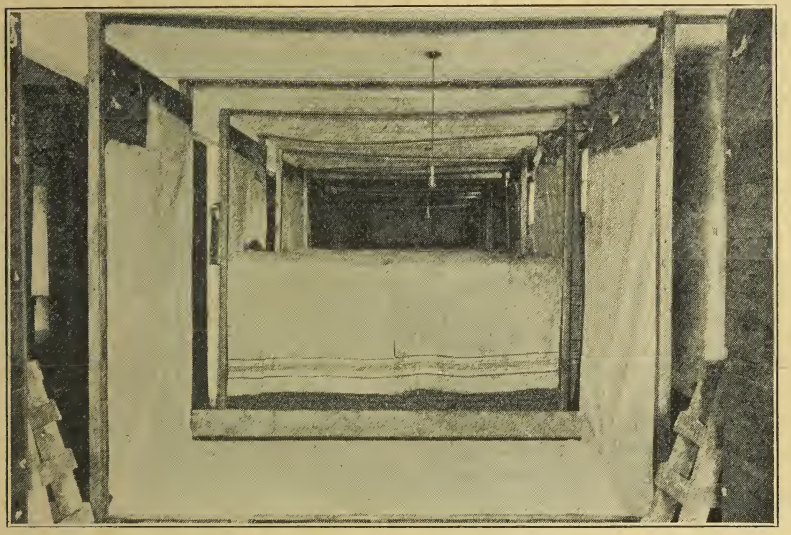

FIG. 20.—BULK FERMENTATION
Before being packed into the boxes the leaf is sometimes "bulk-sweated" in larger quantities to hasten the fermentation process and to reduce the danger of damage in the boxes.

a better purchase price. The grower soon establishes a reputation among buyers as a good or poor "handler" of tobacco and this eventually reacts on the price paid, whether the crop is bought on the field or in the bundle.

ASSORTING AND SIZING

The tobacco crop is usually purchased by the buyers in Wisconsin while it is growing in the field or during the winter months, and occasionally later in the season. The assorting and sizing, that is, the grading of the individual leaves according to size and quality is usually done in the warehouses by the local packers or dealers in tobacco. The "hands" of the various grades of leaf usually contain 15 to 30 leaves tied together at the butts with a leaf. The various grades are packed separately into boxes holding

three or four hundred pounds each. Here they pass through the fermentation or sweating process, or are packed in large bulks of several thousand pounds where they undergo rapid fermentation before they are packed into the boxes. The leaf is also "aged," stored and shipped to the manufacturers in these same boxes.

FIG. 21.—A PACKER'S SAMPLE
A sample of tobacco usually containing four "hands" drawn from a case is used as a basis of value.

GRADES OF TOBACCO

The grading of tobacco according to size and quality varies considerably in the different packing houses in the state. Ordinarily the farmers' crop is purchased on the basis of one or more of three classes: (1) Binder leaf or sorting tobacco, (2) Stem-

ming goods or damaged tobacco, (3) "Fillers", i. e., sand or bottom leaves. If the grower carefully separates his crop into these three classes, it is usually to his advantage in the long run. If the bottom leaves are "stripped in" the purchaser usually figures 10 to 15 per cent of the total at the prevailing price for this grade. Even a low percentage of damaged tobacco in the crop may result in bringing the price down to that of stemming stock or result in "docking" at delivery. The stemming grade usually includes leaf damaged in any way as by poor cultural or curing conditions, wind, hail, disease or insect injury, high case, and wet or immature leaf. When tobacco is sorted, much of this grade is separated as "rags," seconds, or damaged. The top leaves of the plant are usually heavier in body, darker and not satisfactory for cigar binders. These leaves, usually under 16 inches in length, are classed as "B's" and are sorted out. They may or may not again be sized; and are known in the trade as Wisconsin cigar fillers. The remaining leaf of best quality is sized into hands of approximately equal lengths. These hands are placed into two-inch classes—usually from 16 to 28 inches—so that we have grades known as 3A and 4A up to 8A. In packing houses these grades are packed into separate boxes with the grade and weight stenciled on the box.

FERMENTATION OR SWEATING

Tobacco must go through this process before attaining the proper flavor and aroma. Various complex changes occur about which little is known, but these are apparently a direct result of the spontaneous heating of the bulks or cases of tobacco. The temperature in the fermenting leaf may run up as high as 130-140° F., although usually it does not go higher than 95-120° F.

The fermentation process may be fairly complete in a few weeks where bulking large quantities is practiced, but in the boxes the process may be delayed and not completed until late summer. Tobacco is usually "aged," that is, allowed to remain in the boxes for six months to two years or more after fermentation, as this improves its quality. Damage from "black rot," "must" and molds may occur during sweating.*

*See other Wisconsin Experiment Station bulletins on tobacco.

The Wisconsin Experiment Station receives a number of requests annually from persons growing small quantities of tobacco for their own use who want to know how to ferment it. It is very difficult, however, to ferment small quantities of tobacco properly, since the heat if developed is not maintained long enough to produce the necessary changes. If these small amounts of tobacco can be kept sufficiently and constantly warm for a period of time without drying out it is possible to develop considerable flavor and aroma. To do this the leaf must necessarily be packed in an almost air-tight box and kept in a warm place (95-120° F.) where the heat is fairly constant for several weeks.

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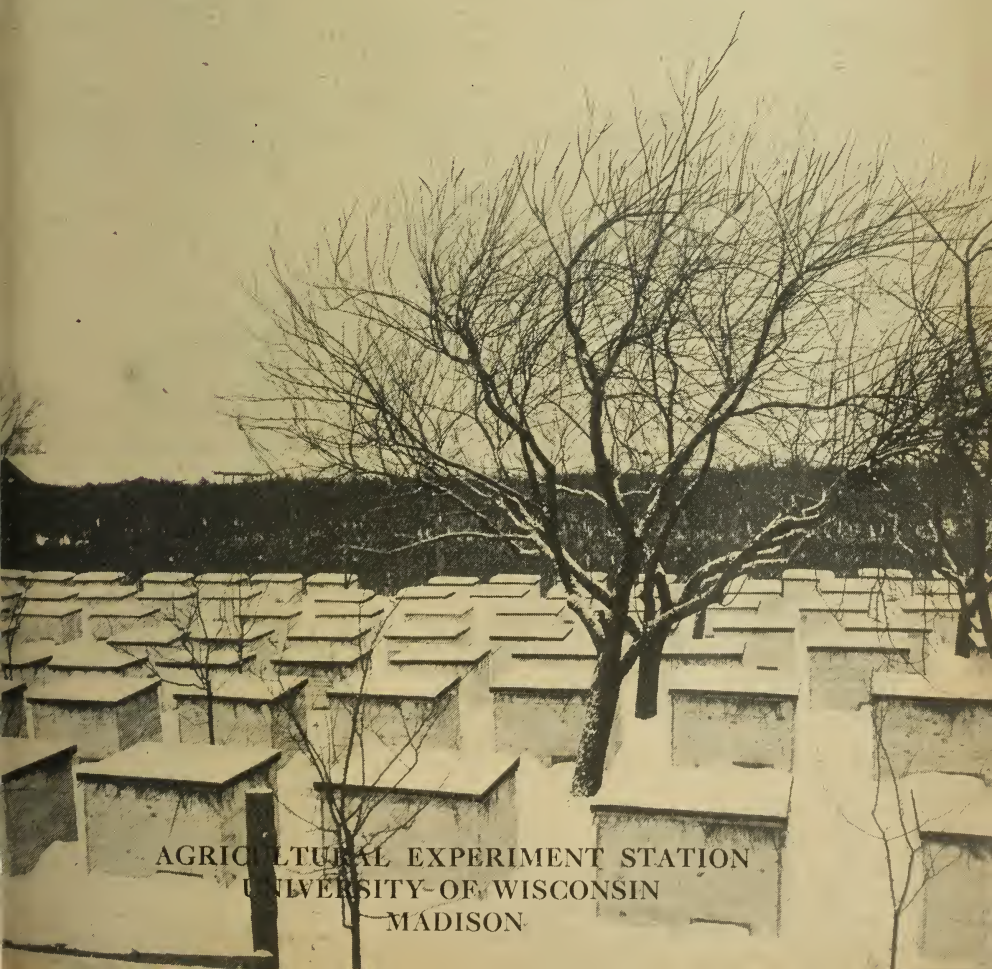
WINTER CARE OF BEES IN WISCONSIN



AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF WISCONSIN
MADISON

DIGEST

Winter loss of bees is the most serious problem among Wisconsin beekeepers. The problem is also serious throughout the northern part of the United States. Page 3.

Successful wintering is possible, however, when a proper temperature is maintained during storage, when a liberal quantity of good stores is provided and when the bees used for wintering are of the right age. Page 4.

The place where bees are wintered makes little difference providing other conditions are suitable. The temperature of the bee cellar must be near 45° F. to 50° F. to give the best results. Page 14

Too much ventilation in the cellar may cause serious losses among the bees in winter. See that the bees are well protected and sheltered from the prevailing winds in spring. Page 17

Put the bees in early and remove them early but give them spring protection. Page 18.

The fundamentals of spring care are: Bees to begin with, protection during April and May; large amounts of stores; and not less than two hive bodies for spring brood rearing. Page 25.

Provide every colony with more stores than you think it can use during April and May. The strong colony will need from 75 to 100 pounds of stores to build up during the spring. Page 26.

Winter Care of Bees in Wisconsin

H. F. Wilson

Winter loss is the most troublesome problem in the bee industry of Wisconsin. The average winter losses for the entire state are from 15 to 20 per cent and sometimes run as high as 30 per cent. Certain beekeepers have reported losses as high as 90 per cent in apiaries of more than 100 colonies. The problem is also serious throughout the northern part of the United States because of the long period during which the bees are shut in without flight.

Successful wintering with very little loss is possible, however, when a proper temperature is maintained during storage, when a liberal quantity of good stores is provided and when the bees used for wintering are of the right age.

Three Distinct Periods of Winter Care

Winter care of bees covers three distinct periods. The first, or fall period, extends from about September 1 to November 20 and is the period of getting the bees ready for winter. During the second or winter period, November 20 to March 21, the bees may be expected to remain in the hives without flight and should not be disturbed except under extreme conditions. The third, or spring period, is from March 20 or the time when the bees are set out until about the middle of May. This is the period for rebuilding the loss of colony strength caused by winter conditions.

With suitable protection, bees can be removed from the cellar on or about March 21 and the beekeeper may plan to examine the bees between March 20 and April 1 if it seems at all necessary. Bees packed out-of-doors will not need to be disturbed until May if properly prepared in the fall. Cellar-wintered bees should be packed as soon as they are placed outside and

on the day of the first flight should be examined to determine their condition.

How Bees are Affected by Winter Conditions

Temperature has a great deal to do with successful wintering of bees, but winter stores and the age of the bees are equally important. Under the very best temperature conditions bees cannot remain shut in over long periods if the stores are not easily digestible.

The fact that bees are able to digest only the sugars from their stores and that all indigestible materials are held in the hind part of the alimentary tract until the bees are able to free themselves in flight, is evidence that successful wintering depends to a very large extent on the quality of the stores. Winter conditions start as early as September in Wisconsin because brood rearing is cut down at that time and may be completely stopped. Normally no eggs are found after October 1, although egg laying in a few colonies may continue until November.

Bees are less active in the fall than in the spring and frequently when the temperatures are fairly high some colonies will have very few bees flying while others are quite active. Low temperatures at night followed by slowly rising temperatures on the following day have a tendency to check the flight of the field bees even when the temperature rises to 70° F. during the day. At that temperature, or slightly below, young bees will freely engage in their play flights. Bees were observed flying when the temperature was as low as 35° F. but it was quite evident that they were suffering badly from dysentery and only a few managed to get back to the hives. Bees commonly fly when the temperature is as low as 48° F.; but perhaps only to free themselves of feces, as individual bees fly out and after a short circle immediately enter the hive again. When the temperature goes as low as 50° F. on the outside of the hive, the temperature in the hive is about 60° F. and the bees are found moving around freely inside.

With the temperatures of 45° F. to 55° F. outside the hives, the bees form a loose cluster. In this they remain more or less together but move about freely; and single bees may be seen moving about by themselves. The temperature at the edge of

the cluster is about 58° F. to 60° F. At these temperatures the bees do not form a definite shaped cluster but arrange themselves more according to the distribution of the stores. If no combs are completely filled with honey, the cluster may extend clear across the brood chamber including eight to ten frames, or if the outside frames are well filled with honey, the cluster may extend nearly the entire length of the hive and cover three or four frames.

Below 40° F. outside the hive, the cluster becomes more compact and rounded, provided the clustering space will permit.

Phillips and Demuth have shown that the temperature around the edge of the cluster is not allowed to get below 57° F. and that lower outside temperatures cause higher temperatures inside the cluster. The temperature within the cluster is developed by the bees through muscular action such as fanning the wings, moving the legs, and other body movements. The upper edge of the cluster will be found just above the lower edge of the honey until the top bar is reached, then the cluster moves sidewise toward the rear of the hive unless the cluster was first formed at that point.

If the temperature surrounding the cluster is not too low, the bees will shift the cluster according to the location of the stores, but it is not uncommon in the spring to find all the bees dead within the form of the cluster and plenty of stores only a few inches from the cluster. This is somewhat common during a severe winter in Wisconsin if bees are left out-of-doors and unpacked. Apparently the bees will not break the cluster when the temperature around them is below a certain point and thus starvation occurs. In such clusters the bees are found packed tightly together with a bee in each cell head inward.

Unless disturbed by some outside influence or unusual condition within the hive, the cluster is never broken so long as the temperature around it is below 57° F. Observations at the entrance of the hive while bees are in the cellar show that the cluster is affected by slight changes in the cellar temperature. During the winter of 1917-1918 it was noticed that wherever the cellar temperatures were below 40° F. nothing could be seen of the bottom of the cluster, but when the temperature was above 50° F. the lower edge of the cluster would extend below the frames to the bottom board and bees could be seen moving about

more or less freely. If the cellar temperature rises to 60° F. or above the bees may be driven to cluster outside the hive.

PREPARING BEES FOR WINTER

Under normal conditions if bees have plenty of good stores and are properly protected they will not need special care in the fall unless it should be to stimulate brood rearing during September. Every beekeeper, however, should know what conditions are necessary for successful wintering and he should see that these are provided.

To begin with, every colony should have a young queen less than a year old, whose greatest egg laying period has not been reached. Then if the bees have a tendency to stop brood rearing in the fall stimulative feeding may be resorted to so that the queen may be kept laying eggs until near the first of October.

The breeding of queens, that not only gather large crops of honey but that also continue egg laying late in the fall, is an important question that has been little discussed. During October plans should be made to provide plenty of good stores. At the same time the bees should be protected—the amount depending on whether or not they are to be wintered outside or inside the cellar. If they are to be wintered outside it is best to provide two hive bodies for the brood chamber; if they are to winter in the cellar, reduce the brood chamber to one hive body.

If the bees are given plenty of good stores and allowed to arrange their own brood nest, no special preparation of the hive is necessary provided either that the bees are well packed or that the temperature of the bee cellar is kept near 50° F. When the temperature outside the hive is between 45° F. and 50° F. the bees move about in the hive more or less freely; and at 50° F. or above, the cluster will spread itself out and the bees can regulate the ventilation according to their needs. If the temperature is as low as 35° F., moisture condenses on the cover and sides of the hive. Below 32° F. this moisture forms ice wherever the warmth from the bees does not keep the temperature above freezing point. Removing the cover and leaving the hive open at the top does not improve the condition of the bees although condensation of moisture may not be in evidence. If the cellar temperature is in the neighborhood of 50°

F. it will do no harm to remove the cover, but below that point the covers should be tight in order to help hold the warmth developed by the bees.

Removing the bottom boards or increasing the clustering space below is unnecessary except for constant temperatures above 50° F. For lower temperatures the smaller opening on the bottom board is best. Every cover should be tightly sealed and there should be sufficient stores in the hive at the beginning so that the bees will not need to be disturbed during the winter.

AMOUNT AND KIND OF STORES

Strong colonies of young bees, given the best quality stores and the right protection may be shut in over unusually long periods without much loss. Stores that contain gums, dextrins, or other foreign substances, however, cannot be digested by the bees and therefore cause dysentery. Most of the honeys produced in Wisconsin are suitable for the bees to winter on—even our fall honey is not bad when free from contamination by honeydew and fruit juices, which the bees gather when nectar is not available. Honeydew is available to the bees in varying quantities from June to October but more is gathered during August and September than at any other time because there is little nectar being secreted by the flowers. Like honey, honeydew varies greatly in color so that it is not always possible to know when it is being carried in.

For this reason it is very desirable that a double brood chamber formed by two hive bodies be used. The honey stored in the upper half of the brood chamber during the early part of the honey flow should be saved and given to the bees for winter stores in October after brood rearing ends. The other half may then be set aside and returned to the bees in the spring for brood rearing.

Feeding Sugar Syrup—Sugar syrup is very satisfactory for winter stores, especially to carry the bees over from the time they are put in the celar until they can fly in the spring. All feeding should be done before the first of November before cold nights prevail. Experiments at the University apiary show that

syrup made of two parts sugar and one part water by weight will be reduced to about two-thirds the original amount, so that if the beekeeper plans to provide 20 pounds of sugar stores for winter he must feed at least 30 pounds of sugar syrup.

How Much Stores Do Bees Need?—By weighing 62 colonies in the fall on the day when they were put in the cellar and again weighing them on the day when they were set out it was found that individual colonies decreased in weight from 3 to 15 pounds and that the average decrease is between 6 and 7 pounds. (These records were made in a cellar registering from 45° F. to 56° F. temperature and about 72 per cent humidity.)

A ten-frame hive with ten empty combs, bottomboard and cover, weighs about 28 pounds and the average colony of bees will weigh about 3 pounds or more in the fall, so that 32 to 35 pounds may be figured as the weight of hive and bees, and all above that as pollen or honey. If a colony of bees weighs 50 pounds at the time when it is put in the cellar there should be ample stores to carry it through until brooding time in the spring unless a very large part of the weight is made up of pollen.

Colonies packed out-of-doors should weigh at least 60 pounds when packed and if the fall temperatures continue high each colony should be examined in November to see that at least 30 pounds of stores are in each hive. The average weight of an empty drawn comb is 1¾ pounds so that the amount of stores in each frame may be approximately estimated by weighing a few frames and deducting the weight of the comb.

CELLAR VERSUS OUTDOOR WINTERING

It might seem that cellar wintering is more desirable than packing bees out-of-doors considering the facts now known about the relation of temperature to the health of bees in winter. Yet it cannot be definitely said that outdoor wintering is less successful than cellar wintering even at the extreme northern border of the state. In fact there seems to be no northern limit in Wisconsin for successful wintering of bees out-of-doors. Beekeepers along the northern boundary of the state report

many years of success with as small an amount as 6 inches of packing. Under proper conditions cellar wintering is probably best, but nevertheless some Wisconsin beekeepers successfully winter bees out-of-doors year after year with even less apparent losses than among cellar-wintered bees. Furthermore, there is considerable evidence to show that the so-called heavy packing of 10 or more inches all around is not as satisfactory as 4 to 6 inches. The heavier packing, however, has not been sufficiently tested in Wisconsin to permit passing judgment on

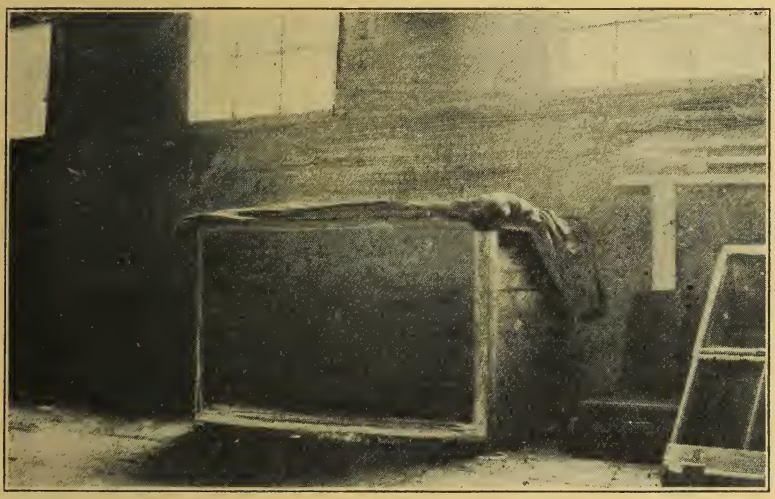


FIG. 1.—COLONIES WINTERED IN PERFECT CONDITION IN THIS BOX

So long as bees are protected, it makes little difference where they are. This box was kept in a lighted basement but the light was shut off from the bees by blankets.

it. It is not advisable for any beekeeper to change his present system if his winter loss does not exceed 5 per cent of the total.

Observations at the University apiary show that much of the success from outdoor wintering comes from the protection given the bees in the spring. Few beekeepers realize that this is essential for the greatest success and fully as important as protection from December to April. During the winter the bees can probably keep up the vital temperature at 57° F. around the edge of the cluster with less expenditure of energy than they can the brood rearing temperature of 93° F. during the spring months.

In the first period the bees are forced to use energy only in digesting food and producing warmth.

In the spring period even greater amounts of energy are necessary to cover a wider range of temperatures. At the same time, additional energy is required for the production of larval food and perhaps wax.

When all beekeepers give spring protection to cellar-wintered bees it will be possible to compare cellar-wintering more fittingly with outside wintering.

Packing bees out-of-doors is a complete system which extends from October until May if done correctly. Wintering bees in the cellar without fall and spring protection is only a part of a system and cannot be used as a basis for judging its success.

Neither can the system be judged unless the facts known about the health requirements for bees under long periods of confinement are rigidly applied. A cellar in which the temperature is allowed to go below freezing offers no protection and is of value only as a windbreak.

The great advantage of having bees packed out-of-doors is that they can have a later cleansing flight in the fall and an earlier flight in the spring than bees wintered in the cellar.

OUTSIDE PACKING FOR BEES

A few beekeepers winter bees out-of-doors without any packing at all and, strange as it may be, some of the colonies manage to survive. However, the loss usually runs from 25 to 100 per cent and the crop production from the remaining colonies is comparatively low.

The majority of Wisconsin beekeepers winter their bees in cellars but a number use packing cases.

Few beekeepers use more than 6 inches of packing all around and many pack with only 3 or 4. It is difficult to recommend the number of hives to be packed together because when the packing is properly done it seems to make little difference except for the cost of the packing cases.

In Sheboygan county where outdoor wintering is more generally practiced than elsewhere in the state and with the greatest

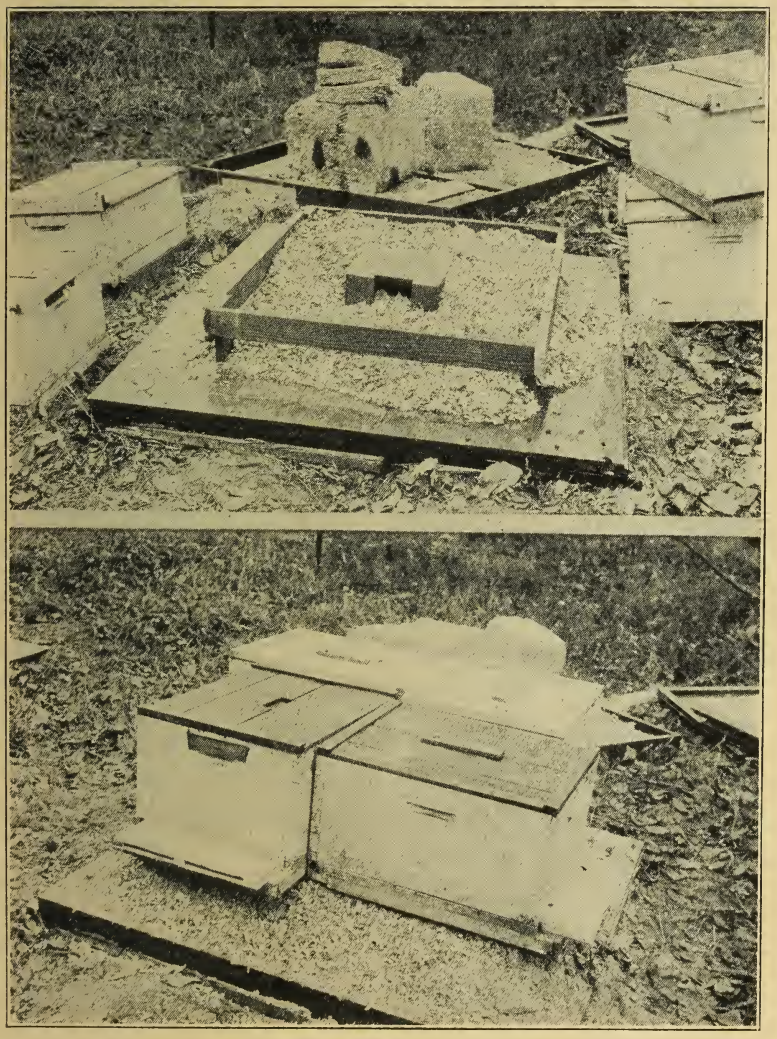


FIG. 2.—THE FOUR COLONY PACKING CASE

Shavings may be used in preparing the bottom packing. (Upper.) In the four colony packing case the hives should be set in this manner preparatory to putting up the walls and filling in the packing. (Lower.)

success, hives are packed singly and only 2 to 3 inches of packing are given. All Sheboygan county beekeepers cover each hive very carefully with several wrappings of newspapers and then fill in with packing. In every case observed where bees were packed in this manner, winter losses have been comparatively small. The kind of insulation, however, seems to play a more important part than the amount, and protection from the wind is equally as important as the packing.

KIND OF PACKING TO USE

Sawdust and shavings make good packing if properly managed. Shavings should be packed in tight while sawdust should be put in loose. Leaves serve the purpose well but should be closely packed.

It is very important that the cases be watertight so that water cannot enter and freeze and thereby damage the power of insulation. Cases have been observed where water had worked through the packing to the hives and formed a solid coating of ice surrounding them.

SHELTER AGAINST WIND MUST BE PROVIDED

Every apiary wintered out-of-doors should be sheltered from direct winds; and cellar-wintered bees should be so protected in the fall and spring. Buildings, trees, or fences high enough to break the force of the winds will serve, or the apiary may be placed in a hollow or below a bluff breaking the winds from the north and west.

PACKING AND UNPACKING

Bees should be packed out-of-doors not later than the middle of October. Normally, freezing temperatures may be expected in October and may continue for several days. Temperatures as low as 15° F. may occur and are sure to come in November. It is a serious mistake to allow bees to pass through several weeks of cold weather before they are packed, and very bad beekeeping to pack them during a protracted cold spell. Pack them early as soon as brood rearing has stopped and on a day when they are flying freely.

Do not unpack bees until May 1 regardless of whether or not it is necessary to work with the bees in the packing cases. It is a good plan to use bags for holding the packing together and then the packing on top of the hives can be shifted with very little trouble. This is also a convenient way of handling the packing and storing it during the summer months.

It is entirely too cold during the entire month of April of the normal year for bees to be without packing.

FIG. 3.—THE FOUR-COLONY PACKING CASE IN USE IN NORTHERN WISCONSIN

This type of winter case with 6 to 8 inches of packing has proven very successful for wintering bees in Wisconsin.

THE BEE CELLAR

Many places used for winter storage were visited, some of which had been especially built for wintering bees, during the investigations made by the Wisconsin College of Agriculture. One of two conditions nearly always existed. Either the storage places were so situated that they failed to give adequate protection and the temperature on the inside was only slightly above that on the outside, or else there was a more or less constant temperature which was not allowed to go below 40° F. The cold cellars were always unsatisfactory and much greater losses occurred in them than in the warmer cellars. A few of

the warmer cellars had not proved satisfactory but the main trouble was caused by light entering the cellars. This always causes the bees to be more or less active if the temperature is high in the cellar.

If bees in storage are kept in absolute darkness and the temperature is held at a constant range of from 45° to 50° F. the size, shape, or location of the cellar makes little difference.

Bees stored in basements with a furnace invariably winter better than bees in outside cellars where no artificial heat is provided.

Cellars having no artificial heat or special insulation should be completely below ground and the ceiling below the frost line. At the same time the top of the cellar should be well insulated from penetration of cold from above.

The entrance to the cellar should be through a vestibule. Both the inside and outside doors should be padded and fitted so that the cold cannot penetrate into the cellar.

It is a good plan to build the workhouse over the cellar and to fill in between the floor and the ceiling of the cellar with shavings or sawdust. A complete layer of a good grade roofing paper under the packing material will help protect the ceiling if it is made of wood. The packing material should be absolutely dry when put in place.

The size of the cellar will depend entirely upon the number of colonies it is to hold. For example, if 10-frame Langstroth hives are used, a space 18 inches by 24 inches should be allowed for each tier of hives and a distance of 3 feet between rows. A cellar 8 feet by 10 feet and 7 feet high will accommodate 50 to 60 hives without crowding. A cellar 14 feet by 16 feet and 7 feet high will hold 150 colonies without serious crowding and 200 if necessary.

Permanent benches of hive stands 10 inches high and strong enough to hold tiers of 4 or 5 colonies should be provided in the cellar.

TEMPERATURE AND HUMIDITY IN THE BEE CELLAR

The temperature at which bees winter best is still a matter of dispute. Many practical beekeepers attempt to keep the temperature at about 50° F. Others claim that this is too high and

that the bees become restless when the temperature goes above 45° F. Perhaps the reason for this disagreement is that other factors necessary for successful wintering have been ignored by those who favor the lower temperatures.

During the winter seasons of 1917-1918 and 1918-1919 careful records of temperature and humidity were made in the University bee cellar. The cellar has steam pipes running through it and a large ventilator entering from the outside, while a smaller ventilator connects the cellar with a warm room above.

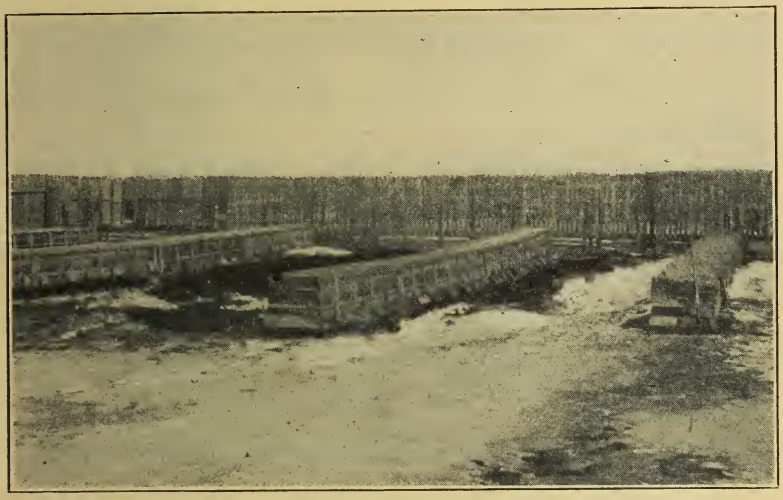


FIG. 4.—CONTINUOUS ROW PACKING

Every other hive faces in the same direction; alternate hives face in the opposite direction. A beekeeper of Antigo, Wisconsin, has wintered his bees successfully in this type of winter case for a number of years.

The walls are of solid stone built completely below ground. In this cellar it is possible to get a temperature of more than 60° F. and a practically constant temperature of 50° F. or lower can be secured by regulating the cold air intake and the outdraft leading from the cellar. In 1917-1918 the bees wintered in perfect condition.

The temperature was kept as near 50° F. as possible except when it was allowed to fluctuate to show the effect on the bees. Only twice during the winter was the temperature allowed to go below 40° F. Both times the covers were lifted from several hives and the bees were found clustered in a compact mass. The

temperature was then allowed to go to 47° F. with the result that the cluster was but slightly spread out. Even at 50° F. it was much more compact than was anticipated. Contrary to expectations the cluster was not broken when the temperature was run up to 58° F. At 57° F. in the bee cellar the cluster was expanded in size and a few bees were found wandering about but the clusters were not broken. Even at 60° F. there was no noticeable change.

During fourteen of the entire nineteen weeks that the bees were in the cellar the temperature varied between 45° and 58° F. From December 26 to 30 the temperature did not go below 50° F. but ran as high as 57° F. From January 17 to 30 the thermometer dropped to 46° F. for three hours; the remainder of the time it varied from 50° to 56° F. From March 18 to April 10 the thermometer dropped once to 49° F. and only twice to 50° F. for a few hours. The remainder of the time it varied between 51° and 57° F. The average humidity for the entire period was about 72 per cent.

The bees were observed daily but showed very little activity except that as the temperature varied the cluster contracted and expanded more or less. Not only did full colonies winter in excellent condition but six very weak colonies, none of which contained as much as a pound of bees, wintered over and were built up into strong colonies the following season.

That not a single comb showed any signs of mildew, which commonly occurs in cellars where the temperature is lower, was another important fact noted.

Therefore 50° F. is not too high for the cellar temperature and if the bees leave the hive in the cellar some other cause must be looked for. On the other hand, it has not been proved that bees will not winter as well at 45° F. However, the losses are much greater in colder cellars than in the warmer ones and bees kept in basements containing a furnace winter much better than those in cellars where no artificial heat is provided.

With a few exceptions, Wisconsin beekeepers who have the lowest winter losses keep the temperature at from 45° F. to 50° F.

If the temperature is kept at 50° F. bees are not greatly affected by changes in humidity although the importance of hu-

midity in the cellar and its effect on the bees is not well understood.

A cold cellar is always damp; and whenever the temperature is allowed to go below freezing a certain amount of frost and even ice will be formed on the underside of the cover outside the space around the cluster. Under these conditions, bees must use an extra amount of energy to keep up the cluster temperature. If the bees were old at the beginning of the winter

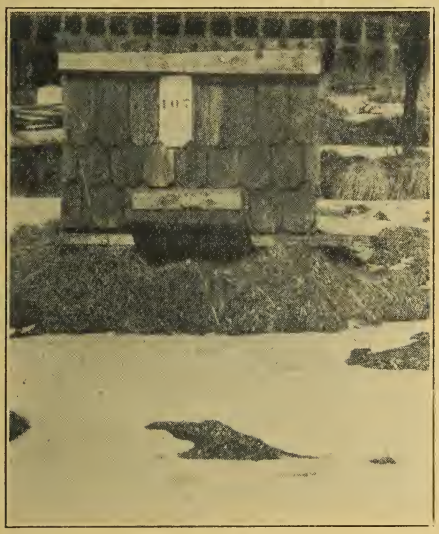


FIG. 5.—A SINGLE COLONY WINTER CASE

This case allows for six inches of packing all around and has been used with great success for many years in the Eskill yard at Iron Mountain, Michigan.

they may not have sufficient strength to build up the colony in the spring. Giving the bees good protection means saving both stores and energy for spring development.

VENTILATION OF THE BEE CELLAR

Do bees need fresh air in the bee cellar? If so, how much and why? Beekeepers have tried for a long time to regulate the health of bees in the cellar by fresh air—perhaps because it is considered necessary for higher animals. The oxygen needs of insects and warm-blooded animals cannot be adequately compared, however, because of their great difference in body struc-

ture and in their method of getting oxygen from the air. Bees should only be compared with other insects; and since it has often been shown that insects may live indefinitely in air-tight containers there is little chance for comparison. Even when the actual oxygen needs of bees become known it is not likely to be of practical importance to the beekeeper. Furthermore, it is not likely that there is a bee cellar existing that does not have sufficient air passing through it for all the needs of the bees.

It is a mistake to believe that bees need special ventilation in the bee cellar to give them air. In fact, most systems of ventilation provided are more harmful than otherwise, because they lower the temperature of the bee cellar. It has been quite noticeable among the bee cellars visited during these investigations that in every cellar where extreme ventilation was given the winter losses were always heavy, and in cellars where no ventilation whatever was provided the bees wintered well nearly every year. In years when the bees did not do so well the beekeepers all agreed that it was due to the poor quality of stores.

A Vernon county beekeeper has two cellars, one with no ventilation and the other arranged so that ventilation can be given in the spring should the bees become restless before putting them on the summer stands. He gives the bees no extra ventilation during the winter and finds that bees winter equally well in each of these cellars. He reports that his winter losses are very small except for the winter 1919-1920 when he lost 30 colonies out of 140 by starvation. He has wintered successfully 180 colonies in a cellar 12 feet by 16 feet and 8 feet high.

A Manitowoc county man winters his bees under his house. There is one window in the outside wall which he covers up with packing and does not open until spring.

This cellar was visited on March 6, 1919, and the thermometer reading was 48° F. The bees were in excellent condition at that time, showed no signs of being restless, and were not suffering from dysentery. This does not mean that bee cellars should be built without some means of ventilation, for it may be necessary to have ventilation in order to cool the cellar if the temperature gets too high.

It also may be found advisable to have some means of lowering the temperature near the end of the season to prevent bees that are suffering from dysentery coming out in the cellar. This

is not a cure but a possible way to hold the bees in the hive an extra week or two until they can be set out-of-doors. Bees that show dysentery early in the winter cannot be saved by lowering the temperature; and the presence of these bees in the hive causes a serious disturbance among those in better condition. The lower temperature causes the consumption of more stores and greater activity which only increases the trouble.

In place of ventilation, give the bees good stores, keep them in a warm cellar, and put them away about November 20.

Moisture running out of the hives is due to low temperatures and excess consumption of stores. Ventilation will not help unless the cellar temperature can be held at 45° to 50° F.

PUTTING THE BEES IN THE CELLAR

Beekeepers differ greatly in their opinions as to the proper time for putting bees in the cellar, but usually they wish to wait until after the bees have had their last flight which keeps them out until Thanksgiving or longer. This is a very bad practice as a rule, for too often the last flight never comes. If full advantage of the bee cellar is to be taken, the bees should not have to remain out-of-doors for two or three weeks of very severe weather at the beginning of the period of confinement. Our observations show that bees may safely take a flight on a sunny day when the temperature is 48° F. in the shade. They do not normally fly on cloudy days, at much higher temperatures. Bees in the shade will not normally fly at 48° F.

A comparison of the weather records for the past ten years shows that on this basis bees had suitable weather conditions for a flight after the first of December only three years of the ten; the latest dates were December 4, 1913, and December 13 in 1920. During the same period the bees might have had a flight only five times after November 20 and three of these years were the same as for the December flights. In 1915, a suitable day for a flight did not occur after November 13.

If the weather is warm during the fall and up to the last of November the bees are likely to have a day suitable for a flight near December 1. But if there is a heavy snowfall in October or about the first of November there is likely to be no opportunity for the bees to fly after November 20. It is quite evident

then that bees have only a slight chance for a cleansing flight in December and less than half a chance after November 20. For this reason the beekeeper should plan to put the bees in the cellar not later than November 20 except in seasons where little or no snow has fallen previous to that date. Following that period the bees should be put in the cellar with the first snow storm.

The season of 1920 was far from normal and bees might have been left out-of-doors until December 20. However, bees in the cellar previous to that time were in no need of a flight; and bees in outdoor cases did not fly to any great extent.

Bees well protected behind a windbreak and with tight outside covers lined with felt or paper may be left out-of-doors until after the first of December.

PUTTING THE BEES OUT IN THE SPRING

The time when bees should be set out in the spring is generally based upon the blooming of the willows; the majority of Wisconsin beekeepers plan to remove the bees between April 1 and April 15. A few beekeepers remove the bees as soon as the snow disappears.

If the bees are given no outside protection the time of their removal from the cellar should be governed by their condition. If they are not restless nor suffering from dysentery they should be kept in the cellar until April 10 unless the weather is warm enough for the bees to fly. If bees are protected by a windbreak and outside covers they may be taken out the latter part of March.

The fundamentals of spring care to get large colonies by the time of the honey flow are: Bees to begin with; protection during April and May; large amounts of stores; and not less than two hive bodies for spring brood rearing.

Here again the weather records of the past ten years indicate how early the bees may be removed with advantage. Bees should not be taken out while the ground is covered with snow. During the eight of the last ten years the temperature was high enough at Madison so that the bees could have had a cleansing flight between March 10 and 15 if the snow had been melted away. However, the snow does not usually disappear before March 15 and after that time a suitable day for a flight is not likely to occur before March 23. Practically every year a warm spell occurs between March 22 and 26 so that if the bees need a

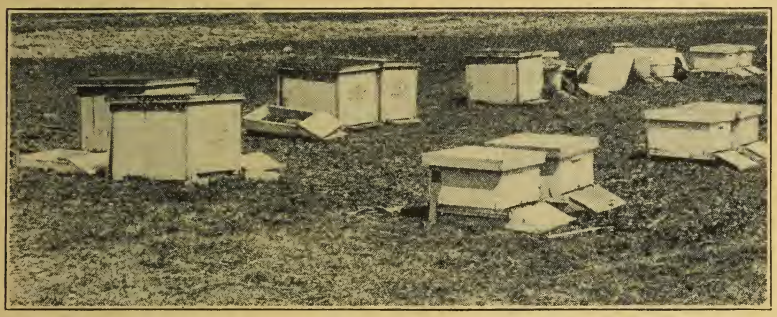


FIG. 6.—AN IDEAL CASE FOR SPRING PROTECTION

The Schmidt packing case, which allows only two inches of packing, has been used with considerable success in Sheboygan County.

flight they may be set out March 20 or sooner, with the assurance that they will be able to fly within a few days. In one year out of ten they may be able to fly before March 10. During the period studied there was one year when a flight was not possible until March 26.

If bees are known to be short of stores they should be set out during the warm spell in March and given an abundance of sugar syrup to carry them over until the time when they can gather nectar in the field.

SPRING PREPARATION FOR THE HONEY FLOW

Very few beekeepers realize how important it is to give the bees exactly the right care from March to June. Many feel that they have done their best if the bees come through the winter successfully and that success or failure depends upon the

season to follow. But what of the one or two beekeepers in the neighborhood who secured a part of a crop although all others failed? Did the successful ones give the bees the needed care in the spring?

It is so easy to provide protection and sufficient stores and the good results are so well known among practical beekeepers that it is sometimes hard to understand why 90 per cent of our beekeepers simply set the bees out-of-doors in the spring and leave them to build up as best they can. Protection and a large

FIG. 7.—ROOFING PAPER PUT ON LIKE THIS GIVES LITTLE PROTECTION

Covering the hives in this way is sometimes recommended for spring protection but unless the roofing completely covers the hive and is tightly fixed all around the bottom it does little good.

amount of stores are fully as important in the spring as during the winter and perhaps more so.

During the winter the temperature surrounding the cluster will be held at 57° F. as long as the bees have stores and energy to live, regardless of the cold outside. During the time the temperature may go below the zero point for short periods but it will range mostly from 20° F. or higher. The bees then need to develop only an approximate average of forty heat units. In addition, they are not at that time required to use energy in the production of wax and food for the young.

As soon as brood rearing starts in the spring the temperature inside the cluster and around the young brood is increased to 93° to 95° F. At the same time the temperature in the northern states will average about 40° F. with fluctuations during March and April up to 65° F. Under those conditions the bees are forced to produce enough energy to keep the temperature up to that of brood rearing, a difference of 30 to 60 heat units. During that time an excess of energy is also being used to produce a larval food and possibly other products.

First Period of Winter Care

(September 1 to November 20)

1. Every colony should have a young queen not more than two years old, whose maximum egg laying period has not been reached.
2. Provide plenty of good stores and allow the bees to arrange their own brood nest.
3. See that the bees are well protected and sheltered from the prevailing winds.
4. All feeding should be done before the first of November before cold nights prevail.

Second Period of Winter Care

(November 20 to March 21)

1. Bees should not be disturbed during this period.
2. Bees in storage should be in absolute darkness and the temperature of the bee cellar held at a constant range of 45° to 50° F.
3. Excessive amounts of moisture will not be apparent if the proper temperatures are maintained.
4. Ventilation of the bee cellar is likely to do more harm than good.

A practical illustration of how temperature influences the development of brood in the spring may be demonstrated by watching three colonies of minimum, medium, and maximum strength. By May the weak colony will have only a small circle of brood indicating the inside space covered by the cluster. This will also be more or less true of the medium colony, but the area of the brood nest will extend beyond the ordinary winter-clustering space. In the strong colony, the brood nest will be several times larger than the winter clustering space and several frames may be filled from end to end.

That strong colonies in the spring are able to build up strong for the honey flow is, of course, a recognized fact. Few beekeepers, however, have carried on trials with protected and unprotected colonies having extra brooding space and more stores than seemed necessary. When this is done the results are remarkable. A lack of such demonstrations is the principal reason why beekeepers who have tried packing the bees out-of-doors have concluded that outdoor packing is better than cellar wintering. The cellar wintering was not at fault, however, but the fact that the bees wintered out-of-doors had spring protection made it appear so. In the northern states the bees are often removed from the cellar and placed in exposed locations where the north and west winds sweep over them causing a fall in temperature outside the hive. This can be made up only by extra work on the part of the bees and the use of energy which should be conserved for a greater expansion of the brood nest. Whenever a cold, wet spring occurs the bees have great difficulty in building up and always reach the honey flow in poor condition unless protected.

April is always cold and the night temperatures frequently drop to near the freezing point. Perhaps there are only a few days when the bees can fly and in that case it is said that bees were unable to gather pollen and nectar and could not build up. This condition would not be necessary if the beekeeper provided abundant stores. Bees do not need to fly more than three or four times during the latter part of March and April; and conditions without the hive have little or no effect on the development of the brood if conditions are right within.

There is also considerable evidence to show that too much packing in the spring is as detrimental as heavy winter pack-

ing. If the packing is too heavy, the heat of the sun does not penetrate to the hive; and the bees do not come out and fly during the few days that are warm enough for a flight.

Some Wisconsin beekeepers who have been content with one hive body full of bees at the honey flow have been amazed to find, during the past two years, that they could get two 10-frame hive bodies full of bees and from 12 to 17 frames with brood at the beginning of the honey flow by following these spring practices. In late May, 1920, two beekeepers actually had most of the colonies in two 10-frame bodies with more bees than could get into the hive. We do not put two bodies on when the bees are first set out but wait until 6 or 8 frames contain brood and then the second hive body is placed on top. As soon as the queen lacks space below, she goes up if the upper body is packed and warm. In spite of evidence to the contrary she will go down again when everything is filled above.

Third Period of Winter Care

(March 20 to May 15)

1. Place the bees in a location where they will positively be protected from a direct wind. Provide some kind of a windbreak.

2. If colonies of maximum strength are desired at the beginning of the honey flow, provide every colony with some outside covering or packing as soon as the bees are put on their summer stands.

3. Provide every colony with more stores than *you think* it can use during April and May. If you do not have combs of honey, feed sugar syrup. Give 40 to 50 pounds because, as a rule, 10 to 20 pounds is about half enough. The strong colony will need from 75 to 100 pounds of stores to build up during the spring, and if the bees cannot get it in the field the beekeeper must supply it.

4. Bees must have brooding room and the beekeeper who has swarms in May should not be proud of the fact, for it is a sure sign of neglect in one way or another.

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ANNUAL REPORT OF THE DIRECTOR
1920-1921
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New Pages in Farming

H. L. Russell and F. B. Morrison

In 1921 the farming industry suffered the severest depression which has occurred in a generation. The sudden deflation which began in the summer of the preceding year and culminated in 1921 was made more prominent by reason of the inflation in prices which had taken place during and immediately after the war. The situation in which the farmer now finds himself, in common with all other producers of raw materials, whether of food, fuel, shelter, or clothing, is that the commodities which he has to sell have gone down in price much more than the finished products which he has to buy. Readjustments in prices following the period of war inflation were inevitable but the quicker this change is effected on *all* sides the better it will be, for if deflation is more pronounced with one class of producers than with another, the equilibrium of exchange is disturbed. The progress of one is then impeded with reference to the other; for after all, prices are only the index of exchange values of labor.

It is to be hoped that the relative price of farm products has reached its lowest level, but whether that is so or not, this outstanding fact remains—the agriculture of tomorrow must more than ever utilize the findings of more scientific methods of conducting our farming operations. When the margins between costs of production and crop returns are wide, less care is likely to be exercised in applying all of those methods which cut out waste, eliminate leaks and losses, and consequently lower costs of production. Profitable farming in the future must more than ever utilize to the fullest all practicable measures to cut not only costs of production but costs of distribuion as well, for unless farming can be made profitable and can insure a reasonable living standard, why should it expect to attract some of our best young men and women.

Wisconsin's farming methods differ from much of American agriculture in that home ownership of the smaller sized land holdings permits of more individual effort than the factory methods of the more extensive and exploitive systems of agriculture. With this more direct individual oversight comes the greater opportunity for utilization of better methods, for as a class, the farm owners and husbandmen show a greater willingness to adopt such practices than the tenant farmer.

FIG. 1.—JOHNE'S DISEASE WORKS SLOWLY

While gradual emaciation, roughened hair coat, and diarrhea are not positive external symptoms of this disease they are indicative of the infection, but Johnin, a test agent similar to tuberculin, must be used positively to identify the malady.

Never were the results of our agricultural experiment stations more needed than they will be in these days of readjustment. Never was there a greater obligation resting upon them so to order their activities as to aid most effectively the needs of those whom they were designed to serve.

The following pages summarize in briefest outline the more important findings of the year. The results that have been fully completed are published in bulletin form or in the agricultural press, but this report aims to show the general prog-

ress of the year in other experimental endeavors, the data of which have not as yet been given to the public.

Johne's Disease Causes Long-Continued Losses

For several years E. G. Hastings (Agricultural Bacteriology) and B. A. Beach (Veterinary Science) have been collecting information concerning the elusive Johne's disease, sometimes called chronic dysentery. It is of so much importance that Dr. Bang of Copenhagen stated, "The future of one of the most important breeds of cattle in Denmark depends upon the ability to eliminate Johne's disease." Several years of experience have shown that this disease is more prevalent than has been supposed, especially among purebred animals, and that it is spreading rather rapidly through the transfer of animals from herd to herd.

In four herds which have been under observation by the College for a number of years, the yearly loss has been from 2 to 12 per cent. One herd of 50 lost during 17 years, 41 animals infected with the disease. Another herd numbering 18 replaced 22 animals in 10 years.

It seems altogether probable that animals are being removed from many herds because of Johne's disease without its real nature being recognized. The slow development, the inconstancy of the most marked symptoms, diarrhea, and the gradual loss of flesh by the animal, are not likely to cause the stockman to suspect the presence of a transmissible disease in his herd. The animal will ordinarily be sold for slaughter and the cause of its decline passed unrecognized. Again the slow spread of the disease in a herd disguises its transmissible nature and makes it difficult to estimate the losses from it. Another dangerous factor of the disease is that it is unknown to many veterinarians and therefore passes unrecognized. It is difficult to grow Johne's disease organisms upon cultures, and at present it is very difficult to prepare large amounts of Johnin, the diagnostic agent used in detecting the disease. The opportunity finally came to the College in June, 1917, to test a known-infected herd with the detecting agent. This test, never before conducted by the use of Johnin in the United States, was the first test of an entire herd ever made, so far as we are able to learn. Johnin is injected into the

jugular vein, and the reaction in the case of affected animals follows quickly, showing, in addition to a higher temperature from five to seven hours after the injection (103°-104° in 25 per cent and 104°-105° in 40 per cent of the cases), other constitutional reactions. The majority of infected cattle exhibit a roughened hair coat from thirty minutes to four hours following the intravenous injection; and at any time between the fourth and the twenty-fourth hours following the administra-

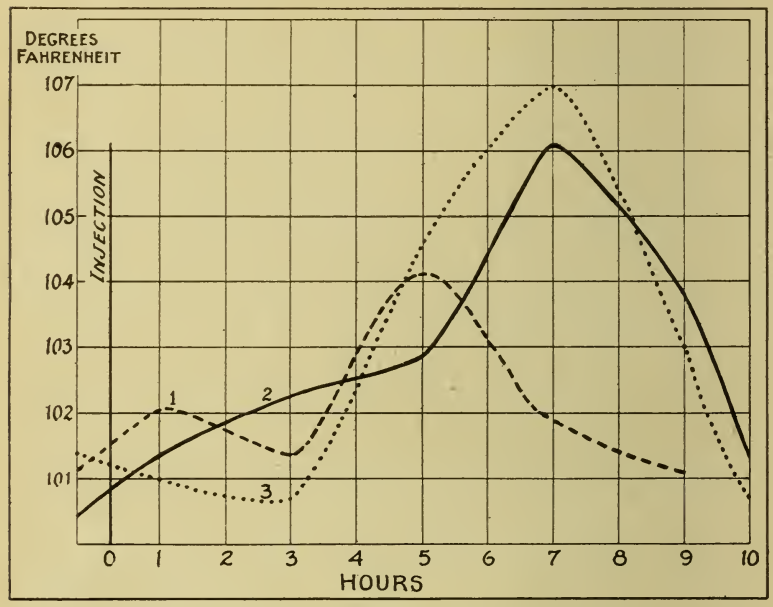


FIG. 2.—JOHNIN INFLUENCES TEMPERATURE

Typical curves show the rapid rise in temperature after injection of the diagnostic agent, Johnin.

tion of Johnin, approximately 25 per cent of infected cattle exhibit a marked softening of the feces. Diarrhea accompanied by a foul odor is often noticed; and muscular tremors and hard breathing may also occur. Three instances out of approximately one thousand cattle tested showed severe reactions, and one animal where symptoms of Johne's disease had been shown for about two months fell prostrate one minute after the injection of Johnin. She remained in an unconscious condition for several minutes, her temperature was 99°, and the pulse was fast and weak; yet, in fifteen minutes she had

sufficiently recovered to be able to regain her feet, and in an hour was apparently normal. A post-mortem revealed the characteristic lesions and the specific organisms of Johne's disease.

One herd of forty-five animals, upon which most work has been done, had been infected for fourteen years previous to the time investigation started, and during that period twenty animals were lost because of the disease. Since 1917 tests have been made twice a year; and, although in June and January, 1921, no reactors were found, it is still possible that in spite of such negative results more reactors will later occur.

Some observations have been made on the rapidity with which the disease spreads in the herd. In 1910 three animals were introduced into a herd. Two of them showed Johne's disease symptoms in 1913. The disease was undoubtedly introduced into this herd by these animals, for during the eight-year period from 1913 to 1921 fifteen animals have been removed because of the disease. Another herd became infected in 1905 through an animal which at that time showed symptoms. Two years later another animal was disposed of because of marked symptoms, and in 1909 six animals were removed from the herd because they were in the last stages of the disease. No other cases developed till May, 1916, when two animals were removed, but between June, 1918, and January 1st, 1919, five clinical cases developed and the animals were sold. During January, 1920, the herd was first tested, and seven reacting animals were removed; while in December, 1920, the test detected eleven victims. Six of these were removed from the herd, and the remaining five retested in May, 1921.

Through fighting fire with fire, work has been carried on, using as the fire fighter the diagnostic agent, Johnin, a product prepared by the use of the specific organism of the disease and comparable to tuberculin in its action on infected animals. From the results thus far obtained, the hope is entertained that Johne's disease may be eliminated from infected herds by the use of Johnin, that this comparatively elusive but contagious and dangerous malady may be eliminated if a description of its symptoms can be spread and veterinarians generally set about to eradicate it.

The bacillus was isolated on nutrient agar which contained human tubercle bacilli and to which sterile blood serum had been added. After several months of incubation two tubes out of a large number showed the acid-fast organisms although the growth was so slight that from the macroscopic appearance of the agar it was difficult to observe any growth. The growth of the bacillus is very erratic—at one time being excellent, while at another it may be very meager.

In order to secure some of the agent, Johnin, a liquid medium was used, and after nine months incubation it was apparent that growth had occurred. At present the basal portion of the medium is a broth in which certain non-pathogenic acid-fast organisms have grown.

Requests for Johnin have been received from New York, Ohio, Indiana, Missouri, Minnesota, Washington, and England, and from practicing veterinarians in this state. It has been impossible to meet all of these demands because of the extreme difficulty encountered in growing the organism. At present enough Johnin is on hand for approximately one thousand tests. The present supply will be distributed in part to workers in other states who may wish to acquaint themselves with the test through its use on herds which are suspected of being infected with Johne's disease.

TUBERCULOSIS IN FARM ANIMALS

Yearly, tuberculosis is taking its enormous toll from the livestock of this state. Not only are cattle susceptible to it, but hogs, chickens, and even horses are stricken down by this malady. Experiments are continually in progress to perfect present methods of detection and, if possible, to find more effective means of diagnosing the disease.

Tuberculosis in Horses. Although horses may acquire tuberculosis, so far only eight cases have been reported in America. Accordingly, when the disease was discovered in a Shetland pony kept as a children's pet on a farm in Walworth County, F. B. Hadley (Veterinary Science) and Mr. Beach attempted to identify the type of tuberculosis found.

Johne's Disease Compared to Tuberculosis

How They Agree

1. Causal organisms both belong to the acid-fast group.
2. In both diseases the animal may show extreme emaciation.
3. In Johne's disease, diarrhea is frequent; in tuberculosis infrequent, although it may occur.
4. Both diseases are chronic in nature.
5. Both diseases are infectious and contagious.

How They Differ

1. Johne's disease is located in the intestinal wall and adjacent lymph glands—usually a limited area of the small intestine. Tuberculosis may affect any organ in the body but only rarely the wall of the digestive tract.
2. Post-mortem lesions in tuberculosis are much more prominent than in Johne's disease. Progress of Johne's disease in individual animals is usually somewhat slower, and the progress in the herd is much slower than in tuberculosis.
3. Nodules are never found as a result of Johne's disease infection, lesions are confined to a thickening of the intestinal wall; while in tuberculosis the formation of nodules is one of the important characteristics.
4. As far as is known Johne's disease is not communicable to man; and of the domestic animals, cattle, sheep, and goats are the only ones susceptible to it. Tuberculosis affects cattle, swine, poultry, and rarely horses, dogs, and cats.
5. Practically the only symptoms exhibited by animals infected with Johne's disease are emaciation and intermittent diarrhea; in tuberculosis the symptoms are varied depending upon the organ or organs affected.

This pony was six years of age and died after it had been on the farm two years. The farmer who had raised and kept her during the first four years of her life said that not only was the dam still alive and healthy but that none of her other progeny had ever shown symptoms of the disease. The pony had never been fed cow's milk, but tuberculosis was known to be present in the dairy cattle on the farm where the pony died. Although not directly associated with the cattle, the infection could easily have come through contaminated feed and drinking water in common troughs. The pony was sleek, fat, and in the best of health until the early summer of 1920, when it began to lose flesh and gradually became debilitated. Even with the best of care, feed, and medicinal treatment no improvement was made, and the pony finally died on December 23.

A post-mortem examination revealed an enormously enlarged mesenteric lymph gland, rather ovoid in shape and measuring about 8 by 10 inches. While considerable pus was noticed when this tumor was cut open, there was no evidence of calcification as is usual in tuberculosis of cattle and hogs. Numerous pea-sized to walnut-sized nodules, resembling the "pearls" of bovine tuberculosis, were observed beneath the serous covering of the neighboring intestine, the abdominal wall, and the diaphragm. No evidence of infection was apparent in the spleen or lungs.

A microscopic preparation of material from the centers of one of the small tubercles was made and stained for the acid-fast miscroörganisms of tuberculosis; literally hundreds of tubercle bacilli were revealed by the microscope. This is in marked contrast to the few found even in very active cases in lesions of cattle and swine. The bacteria were rather longer than the human tubercle bacillus and were distinctly nodulated.

Inasmuch as the organisms seemed to resemble avian tuberculosis, a cockerel was inoculated; but during a period of eight weeks it showed no symptoms of disease, and upon post-mortem examination no lesions were found. Of two guinea pigs similarily treated, one died and the other was killed, both showing the characteristic acid-fast organisms of bovine tuberculosis. Three rabbits were inoculated with the cultures. The first rabbit gradually lost weight and was destroyed ten weeks

after the inoculation, but it was impossible to demonstrate the organism microscopically. The two other rabbits lost weight and finally died, showing the tubercular lesions in lungs and kidneys. This demonstrates that it was the bovine type of tuberculosis rather than either the human or avian type which caused the death of the pony.

Tuberculosis in Hogs. A thorough estimate places the percentage of hogs infected in Wisconsin at 15, although the disease in most cases is not discovered until after slaughter. Occasionally hogs die from tuberculosis and when they do, it is important to recognize the cause of death in order that steps may be taken to control the disease before it has wrought further havoc. In March, 1921, two hogs belonging to the University and kept at the swine barn died. A careful post-mortem, aided by the miscroscope, showed that these deaths were due to tuberculous pneumonia. As there were 120 hogs in this lot of feeders and they were ready for market, it was decided to slaughter the rest of them at once. Post-mortem examination by the federal veterinary inspector at the packing company's plant showed that 34 per cent had lesions of tuberculosis. This, in turn, suggested the desirability of applying the tuberculin test to the breeding herd of 118 swine. Six reacted to the intradermic test.

Tuberculosis in Cattle. An interesting experiment to detect tuberculosis in cattle was carried out by feeding their excreta to pigs. It demonstrated the practicability of locating diseased herds by a system of tagging all hogs sent to central markets in order to trace them to the farms from which they originated and thus find the affected cattle.

Tuberculin Test for Fowls. Mr. Beach and J. G. Halpin (Poultry Husbandry) have brought to a close their investigation with tuberculin as a means of diagnosing tuberculosis and eradicating it from infected flocks. They have concluded: That the hard nodule sometimes occurring in the wattle subsequent to the injection of tuberculin is not an indication of a reaction; that a characteristic reaction is a soft voluminous swelling, sometimes involving the opposite wattle; that the test is not yet perfected to a point where it can be relied upon as a means of detecting all cases of tuberculosis and, there-

fore, has great limitations as a means of ridding the flock of infected members.

ULTRA-VIOLET RAYS AFFECT TUBERCULOSIS VACCINE

A vaccine always implies the use of a weakened or a dead culture of the causal organism. Practically all of the work done in the past in the development of the vaccine against tuberculosis has been with the cultures of the tubercle bacillus that have been in some way or other weakened in virulence. W. D. Frost and Miss Meta Schroeder (Bacteriology) have shown that the tubercle organism in cultures can be killed by ultra-violet light with apparently but little chemical change in its specific bodies. The use of cultures killed by heating, as is the customary method of preparing other types of vaccine, has not obtained general favor, because of the high temperature needed to destroy the organism and the considerable amount of chemical change caused in the cell content. Various mechanical difficulties, however, hinder the use of ultra-violet light. It was first essential to obtain a uniform suspension of the tubercle bacillus, also a method of exposing this suspension to the ultra-violet light. The two difficulties have been overcome.

Experiments were further conducted to determine whether the tubercle bacillus could be destroyed by the ultra-violet light. Thirteen animals were inoculated with the exposed suspension of the tubercle bacillus (exposed to ultra-violet light at a distance of 9 inches for 15 minutes) and two with the suspension before its exposure to the light. The two animals injected with the untreated suspension developed generalized tuberculosis while the thirteen treated animals remained free from tuberculosis. The results thus show the possibility of destroying the tubercle bacillus.

Observations made on the effect of the vaccine in raising the resistance to infection with virulent tubercle bacilli were as follows: Eight animals were vaccinated with a suspension of bacilli killed by ultra-violet light. One month after vaccination they were injected with a virulent culture of tubercle bacillus. A second injection of live tubercle bacillus was given four months later. The animals were killed about one month following the second injection. Of the seven animals

then remaining, three showed no evidences of tuberculosis, three showed a few lesions of the disease, and one was tubercular. Thirteen control animals, that is, those that had not received the vaccine and which were injected with the living bacilli at the same time as the vaccinated group of animals, all developed generalized tuberculosis.

Further experimentation is yet necessary before accurate conclusions can be drawn, but results thus far prove that some protection against tubercle bacilli may be obtained by the use of such a culture as has been prepared by Mr. Frost, with ultra-violet rays.

Abortion of Sows

From a questionaire sent out to 188 breeders of purebred swine, it was learned that nearly 24 per cent had experienced losses from abortion. Of 83 sows and 5 boars tested for abortion, only one of the boars but 51 of the sows (65 per cent) reacted. Although 38 per cent of these sows had already aborted, no sow failing to react has aborted.

To determine the relationships between porcine and bovine infectious abortion, experiments have been conducted by Mr. Beach, who has isolated an organism from two aborting sows in the Station herd and has found it to be a coccus, as is the organism causing cattle abortion. To show whether or not the two organisms are the same, four pregnant sows were infected with porcine abortion germs. Three of these infected sows aborted, while one failed to farrow, yet possibly may have aborted. However, of three other sows infected with bovine abortion germs, all farrowed normal pigs; and of three left as controls, two farrowed normal pigs while the other farrowed fully developed dead pigs. The latter sow and pigs failed to show evidences of abortion infection when tested. These results warrant the tentative conclusions that:

1. The majority of pregnant sows will abort following inoculation with the porcine organism.

2. The abortion organism of bovine origin will not cause pregnant sows to abort.

3. Blood of infected sows will agglutinate antigens of both porcine and bovine origin.

4. Blood of infected cows has a similar effect.

5. Organisms of bovine and porcine origin are morphologically and culturally identical.

6. Abortion of swine is more widespread in Wisconsin than is generally supposed.

With the further experiments now being conducted, it is hoped to determine more specifically some of the methods of control and to gather at the same time more information regarding this dangerous disease.

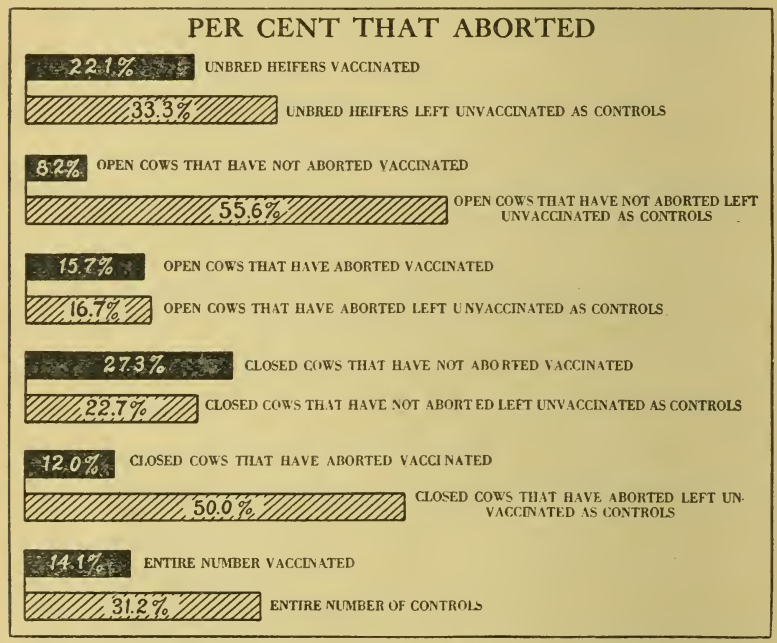


FIG. 3.—ABORTION RATE TWICE AS GREAT IN CONTROLS AS IN VACCINATED ANIMALS

Only 14.1 per cent of the vaccinated cows and heifers available for data aborted, while in the 101 controls that were not treated 31.2 per cent aborted.

VACCINATION AGAINST CONTAGIOUS ABORTION

During the two-year period between January 1, 1919, and January 1, 1921, nearly 1,000 doses of vaccine, composed of live abortion bacilli, have been prepared and distributed through the veterinarians under the supervision of Mr. Hadley. Thus far, reports have been received on nearly 500 vaccinated cattle and 100 controls in 42 different herds in the state.

All of these cattle have been kept under ordinary farm conditions. A careful study of these reports reveals the following results:

Out of 127 unbred heifers that were vaccinated previous to conception 77.9 per cent calved normally, while only 66.7 per cent of those not vaccinated did so. While these results demonstrate the immunizing value for heifers, they are not as satisfactory as was expected. Much more satisfying results were obtained from open cows in infected herds that had never aborted. In these animals the vaccine was 91.8 per cent effective as contrasted to 44.4 per cent in the control animals. The vaccine was shown to have little value when administered to open cows that had aborted, for there was very little difference between the controls and those vaccinated. A higher percentage of cows that were pregnant at the time of vaccination and had never aborted did so subsequently than did the controls which were not vaccinated. No advantage was obtained in vaccinating cows that had aborted and that were pregnant at the time of treatment over those which were inoculated before being bred. Out of a total of 474 cows and heifers vaccinated, data were obtained on 439, only 14.1 per cent of which aborted; while of the 101 controls that were not treated, 31.2 per cent aborted, thus showing that the abortion rate was twice as great in the controls as in the vaccinated animals.

These experiments indicate that abortion vaccine had a decided immunizing value, especially for cattle of certain groups; trouble with retained placenta is reduced; and vaccinated cattle show a decrease not only in the abortion rate but in the sterility rate as well, for there is a marked increase in the breeding efficiency of the treated animals.

Swamp Fever Seasonal Malady

In July 1920 a fatal disease of horses on a large farm in Wood County was reported to Mr. Hadley. He visited the farm and found that the first horse died about July 1, 1919, and that up to December 1919 approximately 30 more succumbed. After that no further losses occurred until June 1920 when three horses died and nine more showed symptoms. Investigation shows that this was swamp fever, a disease

which is seasonal in occurrence—appearing in June, gradually increasing in virulence during the summer, and decreasing in early winter until it disappears in December, only to return the following spring. Although it usually runs a chronic course, in some animals it causes death quite promptly. Fortunately, it is not very prevalent.

FIG. 4.—FARM HORSES SICK WITH SWAMP FEVER

These horses are in various stages of swamp fever, a disease which caused the death of 70 horses on one large farm in Wisconsin during 1919 and 1920.

The bone-marrow shows areas of dark red discoloration, giving it a blood-shot appearance, the remainder being lighter in color than normally.

PINK SAUERKRAUT CAUSED BY YEAST

The manufacture of sauerkraut or sour cabbage as it is sometimes called is relatively simple, and the resulting product is relished by many people. In Wisconsin alone the sauerkraut industry produces more than 36,000,000 pounds of sauerkraut in a year in addition to that prepared in small quantities in the innumerable households.

In 1920 investigations carried on by E. B. Fred (Agricultural Bacteriology) and W. H. Peterson (Agricultural Chemistry) in coöperation with a pickle and canning company revealed some very interesting points regarding pink cabbage. Although many kinds of microörganisms may be found, lactic acid bacteria apparently are the most important in kraut production, but yeasts are also commonly found in kraut. Some of the canning factories have found it difficult in recent years to secure sauerkraut of good flavor, texture, and color. One of the difficulties encountered was the production of a well-defined pink or salmon pink color. This kraut is an undesired product as it must be sold at a price lower than that obtained for white kraut.

Investigations show that the pink or red color of sauerkraut is due to the growth of certain yeasts, and although these organisms are commonly found in great numbers in kraut, they frequently fail to show any pigment. The production of pigment depends upon many factors, such as the amount of salt, the amount of acid, the temperature, and the oxygen supply. Experiments in which cabbage was allowed to ferment at a low temperature and again at a higher temperature showed that 68° F. or above most frequently tends to the production of a pink pigment. Almost without exception, cabbage fermented in the presence of large amounts of sodium chloride, 3 per cent or more, showed a decided pink color. High acid-forming bacteria produce an environment favorable to the development of the pink pigment.

By carefully observing the salt concentration of the brine and by keeping the cabbage at the proper temperature, it is possible that the growth of the yeast which produces the pink pigment can be avoided.

Factors Influencing Growth and Inoculation of Legumes

The soil-building value of legumes has long been known, and they have been used by farmers since early history. Recently attention has been directed toward learning the best environment for legumes. During the past year O. C. Bryan (Soils and Bacteriology) studied the effect of acidity and alkalinity (lime content) on the growth and inoculation of soybeans, both in solution and in sand cultures. It was

learned that some plant growth took place at the reaction slight acidity (pH 3.9), and also at the maximum acidity (pH 9.6). The range in which growth is possible is a wider one than would be found in soils, although the best growth was obtained when the solutions were neutral or very close

FIG. 5.—SOIL ACIDITY INFLUENCES SOYBEAN GROWTH.

3—Extreme Acidity
4—Strong Acidity
5—Medium Acidity
6—Slight Acidity
7—Neutral

to neutral. The development of nodules on the plants took place only within a much narrower range of reaction; namely, from slight acidity to slight alkalinity, proving that inoculation should be successful in any soil which will permit a fair development of the soybean plant.

Different Inoculation for Different Legumes. The most successful inoculation with cultures occurs when the organism has been taken from the nodules of the same kind of plant which is to be inoculated. Bacteria from alfalfa and sweet clover and from peas and vetch can be interchanged favorably, but soybean and clover cultures cannot.

Inoculating Canning Peas on Fertile Soil. The results obtained with the assistance of Mr. Bryan were marked when inoculating peas to be grown on soil of relatively high fertility. On one of the plots (Miami silt loam which had been under cultivation for only three years) the inoculation increased the yield of plants. Although there was no particular increase in the weight of the peas, the nitrogen content, on the other hand, from the peas of the inoculated plot was considerably higher than that of the peas from the uninoculated.

Plots on the Carrington silt loam, which had been in tobacco and clover for six years and were in a high state of fertility, showed some increase not only in the total weight of the plant but also in the nitrogen content of the top due to inoculation, while the weights of the pods and peas were the same. However, due to the fact that the dampened inoculated peas would not feed as freely in the drill, the number of plants on the uninoculated area was much greater than on the inoculated. Had the number of plants been the same on both plots, it is certain that inoculation would have shown a decided improvement. With bacteria, 575 plants yielded a dry weight of 2,055 grams with a nitrogen content in the tops of 3.67 per cent and in the seeds and pods 4.42 per cent. Uninoculated, 711 plants yielded only 1,858 grams with 2.17 per cent of nitrogen in the tops and 3.31 per cent in the peas and pods.

ACETIC AND LACTIC ACIDS FROM CORNCOBS

If the yields on a commercial scale should prove equal to those obtained in the laboratory, it is estimated that every ton of corncobs would be capable of yielding more than 300 pounds of acetic acid and 320 pounds of lactic acid. The discovery of this process by Mr. Fred and Mr. Peterson during the war deserves consideration not only as a war process but as a peace time method for the commercial utilization of corncobs as a source of organic acid. When cobs are partially hydrolyzed and the resulting sugar solution inoculated with the proper bacteria, almost equal quantities of acetic and lactic acid are obtained. The commercial development of this industry will, of course, involve numerous chemical and technical problems, but the possibility of producing chemicals in this way was proved when over 5,000,000 pounds of acetone were obtained by a fermentation process during the war for use in making explosives. The bacteria used have certain characteristics such as rapid growth, ability to produce large amounts of acid and to compete successfully with other organisms, which makes them peculiarly adapted to this proposition. In the United States alone more than 20,000,000 tons of corncobs are produced annually, some of them are used in various stock feeds but generally they are discarded or used for fuel and thus this new discovery has great possibilities.

The acids are obtained by fermenting a syrup made from corncobs hydrolyzed with dilute sulphuric acid. This hydrolysis is easily brought about and yields from 30 to 40 per cent of xylose. Crude xylose syrup is rapidly fermented by certain microörganisms such as *Lactobacillus pentoaceticus* with the production of these acids. The process is very effective, for about 85 to 90 per cent of the xylose can be accounted for by the two acids. In peace time processes, acetic acid and lactic acid are very useful particularly in the tanning of hides and the manufacture of acetone and other chemicals. Inasmuch as these industries are permanent, we may expect these two acids to become more and more valuable.

METHYLENE BLUE REDUCTION TEST

While thus far the butter fat content of milk has formed the most important basis for payment, yet milk supplied to city consumers ought sooner or later to be tested for its bacterial

FIG. 6.—INOCULATION HELPS CANNING PEAS

Five uninoculated plants of Horsford peas on left (1), and on right five inoculated (2).

content. The cheese industry at the same time must expect to use prevention rather than the cure by pasteurization, which has proved so effective in eliminating the bacteria in butter making and for ordinary milk distributing systems.

One of the tests, according to E. G. Hastings (Agricultural Bacteriology), which seems to give most promise is the methylene blue reduction test. It is simple and inexpensive, being based upon the fact that when methylene blue, a dye, is added to the milk, the color disappears more or less quickly according to the bacterial content and the temperature at which the test is made. If all other factors are the same, the time required for the color to disappear will be determined by the number of bacteria in the milk and by their ability to grow in it. For example, a milk containing comparatively few bacteria may not destroy the color of the dye in less than ten or twelve hours, whereas a milk with great numbers may bring about the change in as short a time as five or ten minutes.

The methylene blue test is of great value in determining the quality of milk for Swiss cheese making and forms a valuable supplement to the fermentation test or the curd test for this purpose. A milk may be quite low in bacteria, the great majority of those present may be gas formers and the milk will give very poor results in the fermentation test, while another milk may give a very good fermentation test and a rapid color loss in the methylene blue test. The latter milk may not be as good for Swiss cheese making as the former, due to the fact that by the use of good whey rennet, or by the use of the artificial cultures, the few gas-forming bacteria can be overcome easily. The poorest milk, of course, is that which is high in bacteria, and in which the majority are of the gas-forming type.

In the Swiss cheese industry where it is so necessary to avoid large numbers of "gas-formers," the cheese maker will be able to grade his milk far more accurately than formerly, by the combination of the methylene blue test and the fermentation test. Both of these can be made in the same tube with the sample of milk. Outfits have been supplied to a number of factories in the Swiss cheese district. The results obtained with the test are apparently very favorable. The test is readily applied, and there seems to be no opportunity for the cheese maker to do injustice to a patron through its use.

However, so many variations in the technique of the test have been used by different investigators that the entire work has been confusing. In an effort to remedy this, Mr. Hastings, Miss Audrey Davenport, and W. H. Wright (Agricultural Bacteriology) have determined a standard method for making and reading the test. A stock solution of methylene blue is prepared by dissolving one part of crystalline dye in 2,000 parts of water. From this, a portion is further diluted until the concentration is 1 to 20,000; thus 1 c. c. in 10 c. c. of milk gives a dilution of slightly over 1 to 200,000. The tubes used should be only half-filled by the test and should be cleaned and steamed or boiled shortly before using. After adding the dye, the contents of the tube are mixed by closing it with the thumb or palm, inverting once or twice. (An infection from the thumb can be prevented by wiping it with a clean towel.) The only apparatus needed is a water bath which can be kept at blood heat. While it is not possible to determine accurately the exact number of bacteria, the relative rank of the samples can easily be read. The number of observations made will be determined by the grades into which the milk is divided, and ordinarily there will be little use of extending the period of observation over six hours.

Spoilage of Evaporated Milk

From a number of samples of spoiled evaporated milk submitted to the Bacteriology Department from different condensing factories in the state, two general types of spoilage have been observed on storage by Mr. Hastings: First, the development of a very firm curd; second, the development of a bitter taste. Many of the cans show few or no organisms either culturally or on microscopic examination, and in many instances positive results were obtained only when large quantities of the milk were used for the inoculation of the various media. Recent work has shown that spores of certain aerobic (requiring free oxygen) organisms are the most difficult forms to destroy in the canning process. The organisms, when grown under aerobic conditions, decompose the milk more completely. By inoculating these same organisms into cans of evaporated milk which were then resealed, it was possible to duplicate exactly the results which were noted in the

cans submitted. The limitation of the degree of heat that can be used in the sterilization of milk makes it difficult to overcome these troubles unless some way of exhausting the can be devised. When canning practically all types of fruits, meats, and vegetables, the cans are so thoroughly exhausted of oxygen by the use of heat that even those aerobic spores which resist the treatment cannot germinate.

Evaporated milk is placed in the cans after the milk has cooled, however. If exhaustion of the can is made, a limited supply of oxygen is always present to permit growth. As the oxygen is used up, growth stops, the cells disintegrate, and the enzymes are set free. The amount of enzyme is sufficient to cause only a limited decomposition in the milk, and on an examination of such a can it may be found sterile although bacterial growth had previously taken place.

REMEDIED TROUBLES IN EVAPORATED MILK

During the past, milk condenseries have experienced much trouble in the normal process of canning milk. H. H. Sommer (Dairy Husbandry) has continued his investigation, applying to evaporated milk at condenseries the observations he made in the laboratory on sweet fluid milk in order to discover the reasons for coagulation. He has particularly studied the question with reference to the acidity, the total solid contents of the milk, and the composition of the various milk salts, as well as the effect of heating a synthetic case in solution in the presence of various combinations of salts.

At condenseries observations were made on the effect of the addition of sodium citrate, sodium and potassium phosphate calcium chloride, and sodium bicarbonate on the coagulation of the evaporated milk during the sterilizing process. It is during sterilization that the trouble most frequently occurs in the condenseries. Condensery owners in the past have blamed a number of sources, such as improper care of the milk and extreme acidity. Now Mr. Sommer has found that sodium citrate, sodium and potassium phosphate, and calcium chloride, although normal constituents of milk, have a very decided effect on coagulation. In the past, condenseries have added sodium bicarbonate whenever coagulation appeared, regardless of whether or not it was due to the acidity of the milk.

Sodium bicarbonate seems to function in two ways: First, by changing the reaction of the evaporated milk; second, by counteracting the effect of an excess of calcium salts. In one case, it was found that the addition of sodium bicarbonate, a practice general in condenseries for many years, may in certain instances be harmful rather than helpful, as it may hasten the coagulation of the evaporated milk during the sterilizing process.

The proper amount of any of these salts needed to improve the evaporated milk may easily be obtained by taking a series of samples and adding the salt in question in increasing amounts. When these samples have been sterilized in the usual manner, an examination of the evaporated milk will indicate the optimum amount of the salt to be used. In many cases results of one day enable the worker to anticipate the necessary addition for the next day; and whenever this is possible, the salt should be added before the milk is concentrated, thus insuring a more uniform and more effective distribution. The particular value of these tests is that they will enable the testing of each batch of condensed milk product before it is canned, thereby offering a means of determining the correct amount of citrates or phosphates that should be added.

Conclusions on Coagulation. At the factories visited during the year it has been demonstrated that the three normal milk salts, sodium citrate, sodium or potassium phosphate, and calcium chloride, when added to evaporated milk in small amounts have a decided effect upon the coagulation during the sterilizing process.

An excess of either of these salts hastens coagulation. Sodium citrate and sodium or potassium phosphate have a balancing effect against the action of the calcium salts, that is, they prevent coagulation caused by an excess of calcium salts. Thus, if coagulation is caused by an excess of citrates and phosphates, it may be prevented by an addition of calcium salts, for the effect of these two salts seem to balance each other, and apparently it is necessary that they be present in some definite proportion if the condensing of the milk product is to be successful.

SOLIDS AND FATS IN ICE CREAM CALCULATED BY EASY FORMULA

Ice cream makers at the present time use considerable quantities of milk powder, condensed skimmilk, butter, and cream —quite a different combination from that formerly used in making ice cream on a small scale. The simple ice cream mixes in which no condensed milk or dairy products other than sweet cream are used can easily be standardized so that they contain a definite percentage of fat. The ice cream maker even at the present time has no difficulty in getting what he wants in his simple mixes, but within recent years the ice cream makers' "mix" has become so complicated that it requires considerable attention.

Thus far, the formula suggested for making a mix which shall contain a definite percentage of fat and of solids simultaneously, has been an algebraic one, too complicated for the majority of ice cream manufacturers to use. Mr. Sommer, however, has solved the problem by suggesting the following:

$$X = \frac{B\,C + 8.9A - 8.9C - A\,D}{0.911C + B - .911A - D}$$

A = the per cent of fat in the condensed milk product.
B = the per cent of solids in the condensed milk product.
C = the desired per cent of fat in the mixture.
D = the desired per cent of solids in the mixture.
X = the test of the cream to be used in making the mix.

A, B, C, and D are known in any given calculation so that the value of X, the test of the cream to be used in making the mix, can be calculated by simple arithmetic. The value of X is the test of the cream required so that, when the cream is mixed with the condensed milk product in the proper proportions, the desired fat and solids content are obtained in the mixture simultaneously.

FAKE TEST VERSUS THE BABCOCK MILK TEST

From time to time some investigators have proposed a new test for butter fat which, it is promised, will not only prove more useful than the Babcock test but also more efficient and accurate. After thirty years, however, all efforts have failed to produce a tester more satisfactory than that invented by Dr. Babcock in 1891.

Recently a tester called the Bickley and Gray Milk Tester was presented for investigation to the Dairy Department.

This test is simply a promoters' scheme to sell a hoax to the people of Wisconsin, for in 28 tests made under different conditions by L. C. Thomsen (Dairy Husbandry) the results were sometimes far below the ordinary tests for the Babcock and at other times far above it. No exact variation could be found. Of the first three samples given, all contained 3.1 per cent fat by the Babcock Test, while the Gray spindle gave the results of 3.8 per cent, 5.00 per cent, and 4.3 per cent. Of three other samples of milk the Babcock test was 4.8 per cent fat, the Gray test 3.5 per cent, 3.5 per cent, and 4.2 per cent. The fault of this test lies in that the specific gravity of samples of milk testing the same percentage of fat will vary considerably. This is simply a specific gravity spindle.

The changes which occur in the specific gravity of milk an hour or so after milking, as well as the variation in the percentages of solids-not-fat in samples of milk due to the difference in lactation period of the cows and to the normal characteristics of the milk secreted by different cows, make it absolutely impossible to accept the results of the Gray test as a correct figure for showing the percentage of butter fat. This Gray test is certainly in error and should not mislead anyone into a belief that his butter fat content is lower or higher than that which may be obtained by the regular Babcock test.

Whey Butter Versus Milk Butter

Much discussion has recently centered about the statements that there is no way known to the chemists to identify whey butter from other butter for the purpose of convicting a violator of the whey butter label law. To determine the relative value of these two methods, J. L. Sammis (Dairy Husbandry) made 36 lots of butter. In making each of these lots a vat of whole milk, such as is regularly delivered by farmer patrons at the University creamery, was first well mixed, then divided into two parts; one part being run through a centrifugal cream separator, and the cream ripened with a starter, churned, and a ten-pound package of the butter saved for observation. A second portion of the mixed milk was made into cheese by the regular cheese factory methods for making

American cheese, and the whey was skimmed with a centrifugal whey separator. The whey cream was ripened with the same starter as the milk-cream and a ten-pound package of whey butter held for observation in the same way as the whole milk butter. The two lots of butter were made daily from portions of the same mixed milk so that an equal sanitary quality and bacterial infection in the two lots of butter was assured; experiments were made two or three times weekly between March and May, 1921.

The lots of butter made in the experiments were placed in the creamery refrigerator and scored when fresh; then again at intervals of two or three months after the butter was made. Twelve different judges who were kept in ignorance of the method of making were employed to score the butter. A statement of the butter scores shows that the jars of whole milk butter were scored 342 times, those of whey butter 341 times; that the average of the milk butter scores was 88.98, and of the whey butter scores 90.11. The whey butter had a slightly higher average score than the milk butter.

This difference in the score of the two butters may be explained by the fact that, in cheese making, 95 per cent or more of the bacteria in milk are retained in the cheese curd, and only a small proportion of them escape into the whey. Thus whey butter contains a smaller number of bacteria from milk than the milk butter, and consequently the quality of whey butter may be better than that of the whole milk butter. The small amount of rennet extract which may have been present in the whey butter did not tend to depreciate its quality. Further, chemical analysis showed that the two butters contained approximately the identical per cent of casein. The conclusion therefore, follows that nothing in the normal process of making whey butter makes it inferior in quality to whole milk butter.

SWISS CHEESE MAKING

Due to the general lack of milk inspection at Swiss cheese factories, milk used in making Swiss cheese is often unclean or over-ripe, and as a result a great deal of trouble is often occasioned, and many losses are sustained by Swiss cheese makers. Mr. Sammis has continued his investigations of Swiss cheese making, taking up inspection methods, the effec-

tiveness of eye-forming cultures, the possibilities of handling night milk the same as morning milk, the relation of richness of milk to the quality of Swiss cheese, prevention of gas holes under the rind, comparison of tests used for selecting milk, factors affecting the Swiss cheese making process, and the cause of soft decayed spots in Swiss cheese.

Small holes in great numbers often appear on the rind and not in the interior of Swiss cheese. Experiments are now being conducted to determine whether the application of hot metal press boards to the top and the cooling of the cheese at the sides will check the gas formation at the surface. Soft spots in cheese may be caused by: (1) the formation of lumps in the curd due to rapid heating while soft, (2) settling of curd and improper breaking up after it has stuck together, (3) uneven temperature and coagulation of milk in the kettle. They may be caused experimentally by dropping lumps of soft curd into the cheese before dipping. The eye-forming starter which has been recommended by the U. S. Dairy Division is now being tried out by the cheese factory at this Station. However, before starters are likely to be successfully used in commercial factories, it is necessary that the workers learn to handle them and learn also the inspection and selection of milk that is fit for Swiss cheese making.

Cheese Yields and Cheese Factory Payments

The "pooling system," the "straight-fat" method, the "fat plus 2" method, and the "fat plus casein" method of paying for milk at cheese factories have been tested by Mr. Sammis during a period of three years on cheese made from low and from high testing milk. Various methods have been employed by different factories for paying their patrons, but these results show the general advantage of the "fat plus 2" system of payment.

Possible sources of error were eliminated by using milk from the University herd; both lots of milk were strained and cooled alike, stored over night in the same refrigerator, delivered to the cheese room at the same temperature; and further the cheese was made at the same time each day. Thus was insured a uniformity in the lots of milk as to methods of production, cleanliness, temperature of storage over night, and

degree of bacterial ripeness. These precautions were taken so that the respective lots of milk might not be affected in any respect other than by difference in test of the milk. Each lot of milk used was tested for fat and casein, and the cheese from each was weighed when taken from the press and immediately tested for moisture, fat, and casein. The "fat plus .6" or "fat plus calculated casein" method represents cheese assumed to be of a uniform water content, but the other methods of calculating yields assume variable amounts of water in cheese from milk of different fat tests.

1. The actual yield of cheese corresponds most closely to the "fat plus 2" figures and also quite closely to the "straight fat" method of figuring, or to the test of the milk at those factories where there is no greater variation than 0.5 per cent fat between the highest and the lowest test for the same month. When the difference in test between the highest and the lowest patrons is over 0.5 per cent fat, the yield of cheese figured by the "straight fat" method is not in proportion to the actual yield of cheese, because the cheese from the thinner milk contains more water, more casein, and less fat than the cheese from the richer milk. This is demonstrated by the records which show that there is more casein in proportion to the fat in thin than in rich milk, and further, that the casein in the cheese holds a definite amount of water. Consequently the cheese made from low testing milk holds more water, because it contains more casein, than the cheese made from richer milk, which contains more fat. Therefore, the yield of cheese per pound of fat is not the same for thin milk as for rich milk.

2. The relation of the casein to moisture in the cheese was approximately the same figure, being 1.75 in the cheese made from the low testing Holstein milk and 1.77 in the cheese made from the higher testing Jersey milk.

3. In regard to the yield of cheese from high testing (4.66 per cent fat) and from low (3.25 per cent fat) testing milk, these experiments show that by adding 2 to the test of the milk and multiplying the sum of these two figures by 1.77, the result obtained corresponds very closely with the weight of the cheese obtained. The figure 2 in "fat plus 2" does not necessarily represent the assumed casein composition of the milk, but it is a mathematical constant which according to the experimental results is actually 2.16. The following formula is

suggested for calculating the yield of cheese from milk of any test. Fat percentage plus casein percentage, plus (water percentage equal to) 1.75 multiplied by casein percentage equals cheese yield, in which the 3.5 per cent of added salt is assumed to offset the losses of fat and casein in the whey. The cheese, however, made from the low testing milk contained on the average 2.4 per cent more water, 1.56 per cent more casein, and 3.86 per cent less fat than the cheese made from the higher testing milk.

4. Due to the differences in composition between the Holstein and Jersey cheese, and, because the latter shows a greater food value per pound, the desirability of paying more per pound for cheese from high testing milk is evident. This is done in payments by the "straight fat" method. However, the experiments show clearly that when factories wish to pay patrons strictly according to cheese yield, without taking into consideration any differences in composition of cheese from high and low testing milk, the "fat plus 2" method of payment should be used.

TABLE I—CHEESE YIELDS CORRESPONDING WITH THREE PAYMENT SYSTEMS

Patron No.	1	2	3	4	5
Milk test, fat, per cent	3.0%	3.5%	4.0%	4.5%	5.0%
Yields figured to correspond to:	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Straight fat	7.95	9.275	10.60	11.925	13.25
Fat plus .6	8.30	9.45	10.60	11.74	12.90
Fat plus 2	8.83	9.72	10.60	11.48	12.37

These figures show that the gain in yield of cheese for an increase of 1 per cent in milk fat test should be 2.65 pounds according to the "straight fat" system, 2.3 pounds according to the "fat plus .6" system, and according to the "fat plus 2" system, the gain in yield should be 1.77 pounds.

Use Milk Drinks Instead of Soda Pop

By teaching the use of milk, condensed milk, or milk powder either in the household as home made, ice drinks, or as carbonated drinks at the fountain—thus getting food value of

milk in either case—the demand for Wisconsin's dairy products is being increased.

The homemade drinks, according to Mr. Sammis, are made by placing in a glass any pleasing flavor as vanilla, lemon, or strawberry, which the housewife may have on the pantry shelf. A few trials will show the right amount of flavor to use. Add about two spoonfuls of sugar, and fill up the glass with cold, sweet milk, and put in a piece of ice. This home made milk drink can be had in a variety of flavors to please anybody.

At the fountain the same mixture of flavor, sugar, and milk or milk powder is used as before, but the glass is filled up with carbonated water instead of ice water. It has the same food value as the home-made drink because both are made of milk.

WHEAT SCAB INFLUENCED BY CLIMATE

The wheat scab organism against which it is hoped to breed a resistant strain of wheat is very dangerous, for not only does it cause a loss in the wheat crop, but it often is responsible for a severe blighting in barley, oats, and rye seedlings, as well as the seedling blight and root rot of corn. These losses vary greatly from year to year, depending upon the climatic conditions, but constitute an especially heavy tax on the corn belt as well as the winter wheat areas and the southern portion of the spring wheat section of the central and upper Mississippi valley.

This parasite hibernates in infected "scabbed" wheat kernels and, in addition to remaining in infected seed, persists indefinitely in the soil, developing from year to year on the crop refuse of wheat, other small grains, and corn. Dependent upon the environing condition, the disease caused by this parasite shows a wide range of symptoms. Oftentimes it attacks the seedlings before they emerge from the ground, killing them outright; sometimes the effect is seen by yellowing and blight during the first or second leaf stage; while still others may remain weakened and dwarfed during their later development. These stunted and weakened seedlings of wheat and corn, if they mature at all, usually yield only a small amount of grain of inferior quality.

FIG. 7.—CORN SEEDLINGS KILLED BY WHEAT SCAB PARASITE

At low temperatures (54°F) plants from inoculated seed (1) were all killed before emerging. Those uninoculated (2) grew well but were influenced by the low soil temperature. See Fig. 8.

Experiments made by J. G. Dickson* (Plant Pathology) under both greenhouse and field conditions indicated that the disease in the wheat thrives best at relatively high temperatures (61° F. to 75° F.), whereas the disease in the corn plant made better headway at considerably lower temperatures (46° F. to 68° F.). Curiously enough, however, the wheat plant thrives best at temperatures unfavorable to the development of the scab (46° F. to 53° F.), while corn requires warmer conditions than the scab—or temperatures near 68° F. to 82° F.

The influence of soil moisture was also studied. In a relatively dry soil, containing 30 per cent of the moisture-holding capacity, at a temperature (46° F.) at which the disease ordinarily would not develop, over 40 per cent of the wheat seedlings blighted in comparison with no blight at the same temperature where the soil moisture was 60 per cent of the water-holding capacity. In these experiments seedlings were inoculated with the organism which produces the disease; but, when the disease-free seed was used at 30 per cent moisture, it made a very good growth with only a slight indication that soil moisture was becoming a critical environmental factor.

Time of planting and the effect of seasons are here shown, for both the greenhouse and field experiments have demonstrated that wheat and corn seedlings become attacked by the wheat scab parasite only when under unfavorable environmental conditions such as temperature, moisture, soil reaction, or others, or a combination of several of these factors. Further results show that the two hosts respond differently to at least one factor—soil temperature. Wheat blights in a comparatively warm soil above 53° F., while corn blights in a cool soil below 68° F. Prevention, here, offers the solution of the difficulty and emphasizes more strongly than ever some of the uses already in practice.

1. Plant spring wheat at the earliest safe date in the spring; plant winter wheat at the latest safe date in the fall.
2. Plant corn after the soil has warmed up in the spring and danger of long cold periods has passed.

With disease-free seed and the proper rotation of crops, that is, one in which wheat does not follow wheat or corn, or corn follow corn or wheat for many years in succession, seedling blight can be eliminated as a dangerous disease.

* This work is coöperatively supported by the Office of Cereal Investigations, United States Department of Agriculture.

FIG. 8.—HIGH SOIL TEMPERATURES CONTROL WHEAT SCAB PARASITES.

Corn plants inoculated (1) and uninoculated (2) thrived equally well at relatively high temperatures (75°F). Compare with Fig. 7.

Growers have for some years noted that the disease could in part be checked by planting wheat early and corn late, but no one had found out why this was so.

BREEDING STRAINS TO RESIST WHEAT SCAB

Frequently during recent years the plant pathologists of the College have been able to thwart dangerous plant diseases by breeding resistant strains of the susceptible plant. With work in field plots for the past two seasons, Mr. Dickson has shown that the head blight or wheat scab infection of wheat develops immediately after the flowering period. This parasite forms its spores on decaying crop refuse, from which it is carried by air currents to the wheat head, there to infect at first the anther of the flower after it has opened. Later it develops in the adjacent tissues in the hulls (glumes) surrounding the growing kernel.

Observation again shows that the percentage of scab depends upon the number of anthers which remain within the hull. Most of the important commercial varieties of winter wheat grown in the Mississippi Valley come under this class. Turkey, Kharkof, Kanred, Fultz, and others grown less commonly at Madison, Wisconsin, during the past two seasons have shown high percentages of the anthers held within the glumes and, at the same time, high percentages of the disease. With this knowledge, then, specific effort was directed toward the selection of individual plants from the various varieties having a marked freedom from "open" anthers.

Three strains of Turkey wheat have been obtained which possessed this character. For the past two seasons tests have been made to determine whether such plants showed any increased resistance. It has been gratifying to find that the percentage of scab in some of these desirable commercial varieties that were selected with special reference to this peculiar structure of the anther showed only 2 or 3 per cent of scab as compared with 30 to 40 per cent in the check fields surrounding the plats. Two strains show excellent possibilities and offer hope that further work in breeding this resistant strain of winter wheat will enable our farmers to baffle the infectious organism which is so serious a menace to wheat culture.

Corn Root Rot Causes Heavy Losses

Corn root rot has become one of the most important and dangerous corn diseases not only in Wisconsin but throughout the corn belt. In 1919 conservative estimates placed the loss from this malady at 4 per cent of the total corn crop of the United States or 125,175,000 bushels, and the losses since that date have been equally great. Coöperative investigations with the United States Department of Agriculture have been conducted during the past season with experimental work at Madison, Wisconsin, Bloomington, Illinois, and La-Fayette, Indiana.

The symptoms of corn root rot are very indefinite, depending as they do upon the weather, upon the state of maturity of the corn plant, and upon the parasite which attacks the plant. It has been found that the plant is attacked, not by one organism only, but by several different fungi, all of which are capable of producing a rot of the root system of the plant. In corn three of the chief organisms are: (1) The wheat scab parasite *(Gibberella saubinetii),* (2) the fungus causing the dry ear rot of corn *(Diplodia zeae),* and (3) a corn seedling blight organism *(Fusarium moniliforme).* The first two of these organisms produced a very severe seedling blight of corn, and the wheat scab organism attacked the early planted corn which germinated in a cool soil, whereas the dry ear rot organism attacked the late planted corn which germinated in a warm soil. Together these two parasites often reduce the stand as much as 50 per cent. Even under favorable growing conditions the stand was good, but a number of weak plants developed which failed to form ears of marketable corn.

The elimination of corn root rot disease must occupy more and more attention. The fact that the dry ear rot is primarily a warm climate disease makes it improbable under ordinary conditions that much damage is likely to occur to the corn crop in the seedling or later stages of development as far north as Wisconsin. On the other hand, the rot disease produced by the wheat scab organism is more effective in the northern and the cooler parts of the corn growing areas.

SCAB SPOILS APPLES FOR HOME OR MARKET

Apple scab is one of the most destructive fruit diseases in Wisconsin and, unless controlled, frequently renders crops of the more susceptible varieties practically worthless for home or market purposes.

The spraying experiments by G. W. Keitt (Plant Pathology) were continued from last year in order to determine the following questions: (1) the comparative merits of Bordeaux mixture, lime-sulphur, and dry lime-sulphur for scab control, and (2) the most desirable time and number of spray applications. A series of dusting experiments was added to test comparatively the following materials: (1) sulphur-lead arsenate, 90-10; (2) copper-lime-lead arsenate, 10 80-10; and (3) sulphur-dry lime-sulphur-lead arsenate, 75-15-10, with variations in the time and number of applications.

The particularly dry spring and summer this year so checked the development of apple scab that many of the treatments showed no difference in control. Again, as in other seasons, Bordeaux mixture, 4-4-50, caused a serious russeting of the fruit, while a full program of lime-sulphur, 1-40, and dry lime-sulphur, 4-50, gave a better finished product than did Bordeaux mixture. Although the dust applications usually gave somewhat less satisfactory control of the disease than did the sprays, there was so little scab this year as to render results of doubtful significance.

Dust Treatments for Codling Moth Control. Generally, codling moth control was less satisfactory on dusted than on sprayed plots. During this summer season the study of the life history and the control of the codling moth was carried on at Sturgeon Bay by L. K. Jones (Plant Pathology) employing the same sprays as were used to control apple scab. Four varieties of apples were used in this test; viz., Wealthy, Lubsk Queen, McIntosh, and Snow.

The sprays were applied as follows: Pre-pink, May 8; pink, May 14; calyx, May 30; 10 days later, June 9; summer spray, August 2. Dust treatments were made at about the same times with extra applications applied May 20 and June 18 using the same materials that were applied for scab control. Although the regular program of five sprays of lime-sulphur, 1-40, plus one pound of lead arsenate was not generally satis-

factory in the control of the codling moth, seven applications of dust did not prove as effective in controlling the insect as the five of the lime-sulphur and lead-arsenate spray.

Control of Cherry Leaf Spot

If the total harvest of Door County cherries had been sent fresh to market, 600 cars would have been required to carry the crop. The aggregate value of this immense crop is more than one million dollars and, compared with the 1920 crop, the yield doubled.

With such a valuable crop, insurance by spraying is necessary if the losses from diseases and insects are to be prevented, and for that purpose Mr. Keitt has continued his investigations of cherry diseases. From year to year new methods of spraying have been developed, and now after seven years of experimentation much progress in insuring the cherry crop has been made. The last spring and early summer in Door County were so dry that development of the disease was checked, and at harvest time only traces of it could be found on unsprayed trees. In ordinary seasons such trees have commonly lost most of their leaves by harvest time and usually failed to ripen their fruit. Thus the trees passed through the more critical period of the year without injury from the disease; but during the later part of August a rain, followed by a foggy period of several days, occurred. In a few days there was another rain, and this unusual combination of conditions led to a rapid development and spread of the leaf spot fungus, which brought about heavy defoliation in late August and early September on all plots which received no spray after harvest. While it has ordinarily been feasible to control the disease with only two spray treatments, in such an unusual season a spray after harvesting the crop must be applied. Three applications of Bordeaux mixture, 3-3-50, applied as follows, gave best results:

1. Just after the petals fall,
2. About two weeks later,
3. Soon after harvest.

Bordeaux mixture, 2-2-50, or lime-sulphur, 1-40, gave less satisfactory control than did the stronger Bordeaux mixture.

FIG. 9.—FRUITING BRANCHES AND CANE FROM UNSPRAYED CUMBERLAND BLACK RASPBERRIES.

Severe infection of anthracnose on fruiting branches and canes caused the fruit to become dry and tasteless and will reduce next year's crop of berries. (See Fig. 10.)

The following dusts were tested with varied times and numbers of applications: sulphur-lead arsenate, 90-10; copper-lime-lead arsenate, 10-80-10; and sulphur-dry lime-sulphur-lead arsenate, 75-15-10. In general the dust treatments did not give satisfactory control, although the comparison with liquid spray cannot be satisfactory, because the only severe test came nearly a month after the last treatment.

The results of this season show that it is necessary to give increased attention to the control of leaf spot after harvest.

Anthracnose of Black Raspberries Controlled by Spraying

Wisconsin's black raspberry crop has been greatly reduced by the disease known as "anthracnose," which is particularly dangerous on the Cumberland variety. During the last two seasons work has been carried on at Madison by L. K. Jones, using bordeaux mixture and lime-sulphur with and without the addition of adhesives.

These sprays were applied as follows:

(1) A delayed dormant spray, lime-sulphur, 1-10, or Bordeaux mixture, 6-6-50, after the first two or three leaves had unfolded.

(2) A summer spray, lime-sulphur, 1-40, or bordeaux mixture, 3-3-50, about one week prior to blossoming.

Combinations of these various sprays were used with such adhesives as glue, gelatin, and casein-lime. On plants which had received the same treatment for two seasons, a delayed dormant spray of lime-sulphur in combination with gelatin or glue, or bordeaux mixture with gelatin controlled the disease commercially. Two sprays, timed as outlined above, of lime-sulphur alone or in combination with glue or gelatin also were effective; and bordeaux alone or in combination with milk, gelatin, glue, or casein-lime controlled the disease commercially. On plants which had not been well sprayed the year before, no spray in any single application controlled the disease. Two sprays seemed to be necessary and may be either of lime-sulphur or bordeaux mixture plus the adhesive, but two sprays of lime-sulphur or bordeaux mixture without such an adhesive, as glue or gelatin, did not give good control.

Growers of black raspberries have here a method for preventing the ravages from one of their most troublesome diseases, and

one which year after year has been drying up the young ripening berries and reducing the yield in the small fruit plantings of the state.

EARLY CABBAGE SELECTED FOR RESISTANCE TO YELLOWS

Trials conducted this year at Racine by W. B. Tisdale

FIG. 10.—FRUITING BRANCHES AND CANE FROM SPRAYED CUMBERLAND BLACK RASPBERRIES

Two sprays of lime-sulphur plus gelatin saved the crop. They were applied (1) delayed dormant, after first two or three leaves had unfolded, and (2) a summer spray, one week before blossoming. The disease was excellently controlled, and the crop increased 30 per cent over unsprayed plants. (See Fig. 9.)

(Plant Pathology) were concerned primarily with certain early varieties of cabbage. Interest was centered upon the three new possibilities—namely, Copenhagen Market, All Head Early, and Glory of Enkhuizen. A late variety and two medium early kraut varieties have previously been developed which are yellows-resistant, but the first three named are the only early varieties in which resistance to yellows has been produced. These strains are popular in certain localities where cabbage is grown for the early market or where an early cut of kraut is desired. The first selections were made in 1919 from "cabbage sick" fields and in 1920 seed was produced from a few self-pollinated plants. Plants from this seed were set in "sick" soil in 1921 and all selections showed a high degree of resistance in combination with a fair degree of earliness and good type. The Glory of Enkhuizen selections showed a high percentage of resistance but were a little later in maturing than the commercial parent strain. Further selections from these trials were made in 1921. An effort will be made to grow seed from them in the greenhouse, and trials from these selections may then be grown on "sick" soil in 1922.

Club Root of Cabbage Affected by Soil Temperature and Soil Moisture

The studies on the effect of soil temperature and soil moisture on plant diseases of fungus origin have been extended this year by J. Monteith, Jr., (Plant Pathology) on the club root of cabbage (*Plasmodiophora brassicae*). He grew cabbage plants in club root infested soil held at various degrees of temperature and at various percentages of moisture. The disease developed through a wide range of temperature, 48° F, to 86° F., while the most active development of the disease was at about 68° F. Club root did not develop in most of the soils used when they were held at a moisture content below one-half of their water-holding capacity. At a higher moisture content, the disease appeared in much severer form. Avoidance of poorly drained land for cabbage culture is, therefore, important in controlling this disease.

PEA ANTHRACNOSE FOUND IN WISCONSIN

In two localities of the pea-growing region during 1912 and 1920, F. R. Jones and R. E. Vaughan (Plant Pathology) found great damage caused by the pea anthracnose. At present the parasite appears to be of limited distribution in America, but it readily infects all species of the genus Pisum that were tried. The fungus first appeared in Wisconsin in 1912, but no further outbreak was observed until 1920 although at both times it caused even greater destruction than that commonly caused by any of the well-known pea parasites. Pea anthracnose (caused by *Colletotrichum pisi Pat.*) was first collected in 1891 in Equador, South America, and while the Wisconsin fungus did not agree with the description, a comparison of specimens proved their identity. In Japan the fungus is widespread but causes relatively small damage.

Lesions of the disease on leaves are irregular in shape, smoky gray or brown toward the margin and lighter in color tending toward a brown at the center. On pods the lesions are usually lighter in color, more nearly circular in shape, and dark brown at the margin, while on stems the lesions are elongate, rarely encircling the stem and, when covered with spores, are ashen when dry and copper-colored when moist. Slender bristles or setae are sometimes produced so abundantly upon stems that they can be seen with a hand lens. When the stems are nearly mature the fungus may form, in moist weather, rusty areas of considerable extent where spores are produced in tiny masses.

WARM SOIL REDUCES ONION SMUT

Onion smut is a seedling disease which reduces the stand early in the season. It is disseminated from one locality to another on onion sets or upon the seed. Starting in the eastern states, it has spread gradually across the continent until now practically all large onion sections of our northern states suffer from its ravages. In the southern onion sections, however, which have been equally exposed, the disease has not appeared.

This peculiar situation led to the surmise that the infection of the onion plant by the smut fungus might be favored by a

* In coöperation with the United States Department of Agriculture, Office, Cotton, Truck and Forage Crop Diseases.

low soil temperature. Testing this hypothesis experimentally, L. R. Jones and J. C. Walker (United States Department of Agriculture) found that in a cool soil (60° F.) the progress of the disease was facilitated, while at temperatures of 84° F. or above, the development of the disease was completely pre-

FIG. 11.—TEMPERATURE AND MOISTURE INFLUENCE PLANT DISEASE

With these cases the possible seasonal changes in hot and moist weather can be duplicated in the laboratory.

vented. Moreover, they found that the onion plant is not subject to infection except for only a short period after the germination of the seed. This finding has a definite practical bearing on the fact that in northern sections, where the soil temperature is lower at sowing time, the onion crop suffers more from the disease than in the South, where the onion seed is sown in August and September.

Tobacco Diseases Studied

Wisconsin is the cigar binder state of the Union. While the growing of this crop is restricted to a few counties, the value of it in 1920 was over sixteen million dollars.

During the past year the Horticultural Department has operated three air-control chambers in which plants could be exposed to constant conditions of air temperature and humidity as long as desired. Two diseases of tobacco, mosaic and the so-called "wildfire," a bacterial leaf spot which has recently caused a great deal of concern in the southern and eastern states, have been studied.

FIG. 12.—RELATION OF TEMPERATURE TO PLANT DISEASES

Mosaic. Results obtained by James Johnson (Horticulture) with this disease are especially interesting since they stir up a controversy of long standing as to the nature of the causal agent. Is this transmissible disease caused by an invading parasite too small to be seen by our most powerful microscopes, or is it due to enzyme action within the plant? Air-control experiments have shown that the prevalence of mosaic disease is most marked at a temperature of about 86° F., and while it is practically non-existent at 97° F., at this temperature there is no reason to believe that the amount of enzyme action is less than at the lower temperature. This response to

temperature conditions corresponds quite closely to that of the behavior of a large number of well known plant parasites and increases the probability that this trouble is due to a yet undiscovered organism.

Wildfire. The wildfire tobacco leaf-spot disease was found to develop most markedly between 82° F. and 91° F., although it could infect its host at a temperature as low as 59° F. and as high as 98° F. Its alarming development in this state this summer was no doubt facilitated by the unusual temperature conditions.

Warm Weather Reduces Root-Rot of Tobacco. Recent experiments in the laboratories have shown that relatively cold soil favors root-rot of tobacco; warm soil reduces the disease. Field observations made over a number of seasons have confirmed these conclusions. Warm weather in the summer of 1921 was especially interesting, particularly when compared with the cold growing season of 1915. One of the experiment station tobacco fields which has grown tobacco continually for over fifteen years and is consequently very badly infested with root-rot, grew a good crop of even the most susceptible varieties in 1921 due, undoubtedly, to the influence of the warmer weather. A similar condition was true practically all over the United States this year. As an example of the effect of weather, in 1915, a cold season, the yield of tobacco of six different commercial strains was reduced when grown on rot-infected soil from 50 per cent to 95 per cent; while in the warm season of 1921 the per cent decrease in weight of the same strains grown on "sick" soil was from 15 per cent to 50 per cent. The mean temperature for June, July, and August 1921 was about 10° F. greater than that of the corresponding period in 1915. These field data indicate that temperature exerts a very great influence on rot-infected soil which may cut the yield of tobacco, by reason of the disease alone, more than half. This undoubtedly explains why so many soils may grow an excellent crop one year and fail to produce even a half crop the following year. While the farmer can not control the weather, he can learn many profitable lessons from these results, namely:

1. Rotate your tobacco field, using non-infected land; or else plant disease-resistant strains, for a cold summer may

otherwise permit of unusual rot development in old infested fields.

2. Cropping to tobacco does not wear out the soil; it makes it "sick," but a lot of fertilizer can be wasted in trying to make sick soil grow tobacco in any but the warmest seasons.

Stand-up Burley Developed. The root-rot resistant White Burley tobacco previously developed had drooping leaves. Now the growers want erect leaves or "stand-up" Burley. Accordingly the resistant drooping type was crossed with the erect susceptible type of tobacco, that is, the tobacco which was affected by the root-rot organism. In 1921 the F-4 generation was grown, and several uniform types resistant and erect are now at hand which are very promising.

LATE POTATO BLIGHT KILLS IN WARM WEATHER

By using air control chambers, Mr. Johnson studied the effect of cold moist air conditions and hot moist air upon the infection and growth of the potato blight disease (Phytophthora). Other investigation has shown that chill weather favors the infection while the destructive ability and growth of the disease is worst at 77° F. to 91° F. The investigations show that potato blight disease is a relatively vigorous parasite at temperatures as high as 91° F. to 95° F. Thus, while the disease infection is helped by cool humid weather, it thrives best during warm moist weather.

VARIETIES OF CURRANTS AND GOOSEBERRIES FOR WISCONSIN

Studies to determine the principal varieties of currants and gooseberries for Wisconsin have been conducted by J. G. Moore (Horticulture) for several years. Taking into consideration the yield, size of berries, size of bunches and susceptibility to disease, the following varieties of currents and gooseberries have been found to be most useful in Wisconsin: Currants—Perfection, Pomona, Wilder, Red Cross. North Star is a very heavy producing variety, but the berries are

small. Two varieties of gooseberries which stood out above all the other varieties tested are Downing and Pearl.

Insects Eat Profits From Farmers' Income

During the summer of 1921 serious outbreaks occurred of three different insects—grasshoppers, the corn ear worm, and the northern tobacco worm. The grasshoppers were again bad in the northern parts of the state, especially in Door County

FIG. 13.—CORN EAR WORM IS A DESTRUCTIVE FEEDER

This insect was unusually severe in Wisconsin this year, and although especially injurious to the sweet corn, the field corn suffered as well.

where the loss was estimated at over $200,000, while the corn ear worm was particularly abundant this year, and many samples of injured corn have been sent in for inspection. No specific remedy is known, for the adult moth lays its eggs on the outside of the shuck, and the young worm enters at the end. The northern tobacco worm or tomato worm caused considerable injury to tobacco because the season was peculiarly favorable for its development. Ordinarily only one crop of worms develops from this insect in the spring; but this year, due to exceedingly favorable conditions for growth, a second genera-

tion of worms emerged in the later part of August and September. Control measures, in which a dust application of 1 part arsenate of lead, 8 parts air-slaked lime, or a spray of 2 pounds arsenate of lead to 50 gallons of water is used, prove an effectual means of controlling this trouble.

FIG. 14.—KILL TOBACCO HORN WORMS WITH ARSENATE OF LEAD

Poison the Grasshopper. The long-continued hot dry weather helped to aggravate the situation by drying up the grasshoppers' natural feeding places so that they flew in great numbers to the grain and hay fields. Although many tons of poison bait were used and as a result the loss was greatly reduced, yet many thousand dollars worth of farm products were eaten by the insects. In many cases sawdust was substituted for bran, but the experiments carried on by C. L. Fluke (Economic Entomology) at Egg Harbor in Door

County were not as satisfactory as where bran had been used. The tests with banana oil and salt were found to be more attractive than either banana oil or salt alone. The poison mixture far superior to all the others was composed of bran, arsenic, salt, and banana oil.

The severity of the grasshopper outbreak in some of the northern counties is intensified because many farms are bor-

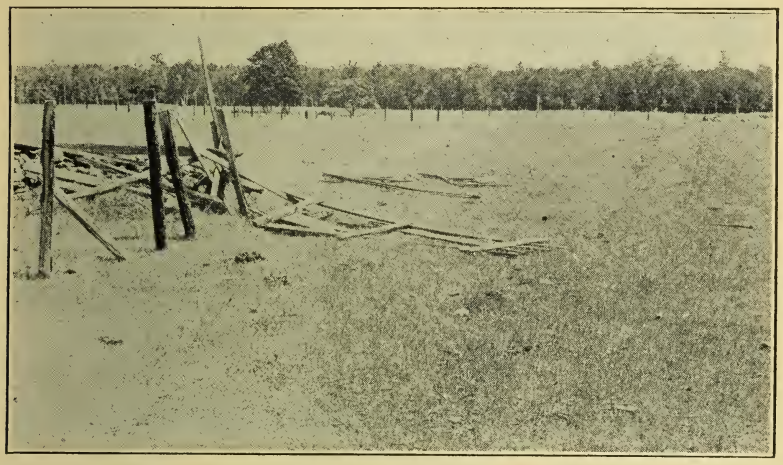


FIG. 15.—GRASSHOPPERS ATE $200,000 WORTH OF CROPS IN ONE COUNTY

This pasture has been stripped of all green vegetable matter by grasshoppers. Poison bait applied not by one farmer alone but by the entire community cooperatively will cut down the ravages of the pest.

dered by waste land (slashings and old pastures) and such property is often owned by non-residents. An attempt was made to hold these pests in check by poisoning a strip a rod or two wide around the cultivated fields, but this precaution proved unavailing. As soon as the grasshoppers develop wings, they fly for a considerable distance into the grain fields, feeding upon the developing heads and in many instances reducing the yield as much as 75 per cent to 90 per cent. A few farmers saved part of their crop by harvesting just as soon as the grasshoppers started their march into the fields; but if best results are to be obtained, the entire community where the pest occurs must coöperate thoroughly to poison the grasshoppers by combined effort.

CHERRY APHIS SAPS STRENGTH FROM TREES

About the middle of July, just as the late cherries were beginning to ripen, the black cherry aphis became so abundant in Door County that many trees shed their foliage. According to Mr. Fluke, who was located for the season in Door County, this sapping of the trees' strength so delayed the process of ripening that quantities of the cherries were unfit for food, being rather bitter and undersized. So severe was this attack that for the first time on record, the leaves began to disappear from the trees. Some were almost bare of foliage, while on others only half of the leaves remained. Coming as

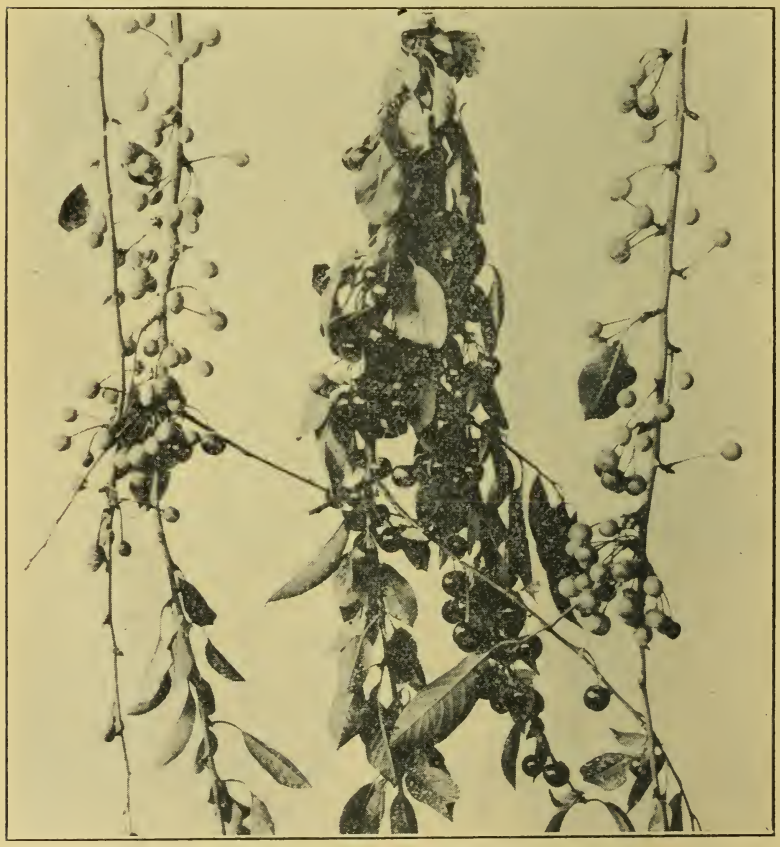


FIG. 16.—HOW THE APHIS CUTS THE CHERRY CROP

The branches on each side were almost stripped of foliage by the aphis, while the cherries were still green. The central branch is normal and shows the cherries almost ready to pick.

it did when some of the cherries were still green, the attack was very serious.

A peculiar characteristic of the situation was the sudden disappearance of the aphis shortly after the injury appeared. The trees began to recover, but how completely they have recovered will be determined by the development of foliage and fruit next summer. Control measures for this test have yet to be determined as it is necessary to decide whether it is best to spray regularly in the spring when the plant lice are first hatching or to wait till the season is more advanced. Nicotine sulphate and soap was used on the aphis this summer in the amount of 1 part of nicotine sulphate to 1,000 of water and 2 pounds of soap to 50 gallons of water.

Pea Moth Threatens Dry Pea Industry

From an acreage of 78,000 in 1909 the area of dry peas declined to 66,000 in 1919 and 56,000 in 1920. While the low market prices undoubtedly have some effect, the hazard of loss from the pea moth has undoubtedly curtailed the production of the crop. In 1920 the production was 1,063,000 bushels compared to 1,165,000 bushels in 1919, although the average yield was at the same time increased from 13.3 to 19 bushels an acre with a farm value of nearly $2,000,000 in 1920. If the safety of this crop can be secured it will mean much for the farmers of upper and eastern Wisconsin.

For some time it has not been possible to say whether the pea moth could be held in check or not, but now proper cultural practices show that this insect can be checked and the injury reduced from 25 per cent to 2 or 3 per cent. Mr. Fluke recommends the following preventive measures:

1. Select early varieties and plant as early in the spring as the soil will permit.

2. Do not plant peas in the same plot or near the same plot two years in succession. Apparently the moths do not fly far and the greater the distance from the old fields where the larvae pupate in the soil the less the infestation. Only too often the farmer across the road puts in peas and offers a tempting place for his neighbor's moths which thrived the year before.

3. About the time of flight of the moths, the winds prevail in a northerly direction, and it has been found that fields which have been planted south, or even east or west, of the previous year's plantings suffer less than those to the north. Neighborhood coöperation will do much to eliminate the pea moth.

BEES AND HONEY ON THE INCREASE IN WISCONSIN

Although Wisconsin had only 96,000 colonies of bees in 1910, on February 1, 1921, it was estimated that there were 121,000 colonies with a total farm value of over a million dollars. With such a promising young industry under way, attention can well be paid to determining the causes of losses and to provide better methods for keeping our colonies free from disease.

Wintering Bees. The successful wintering of bees is one of the most important problems which confronts the apiary owner in Wisconsin. Tests made by H. F. Wilson and J. I. Hambleton (Economic Entomology) show that bees will winter over on sugar syrup alone. The advantage of sugar syrup stores is that they contain less impurities than some honey. When poor, impure stores are used, the intestines of the bee become clogged causing dysentery. To rid itself of this material the bee will fly out into the cellar, become lost and die.

Experiments in the fall of 1920 showed the following results: Bees wintered on both boiled and unboiled syrups came through in equally good condition. It was noted that boiled syrup did not crystallize as quickly as unboiled syrup due to the slight inversion during the boiling process. In tests made to determine how much sugar syrup should be fed to a colony of bees, all honey in the hive was replaced by 30 pounds of sugar syrup. The colony was kept on the scales during the entire operation, and it was found in seven days that the weight of the stores decreased from 30 pounds of syrup to 18 pounds of honey.

Use Package Bees for Restocking. Package bees have been an excellent means of restocking depleted apiaries and in many cases for starting new yards. The packages are shipped from southern states in the early spring and form the nuclei for the colonies which are to build up in time for the honey flow in

June and July. Package bees received from Texas were put in hives containing (1) full sheets of foundation and (2) full sets of drawn combs with a little honey. Sugar syrup was then fed to all colonies until they were able to gather nectar from the field.

The package bees were received on April 25 and immediately placed in the hives, a record being kept of the increase from May 5 to June 10. The results indicated that it is more profitable to use drawn combs for package bees when they are

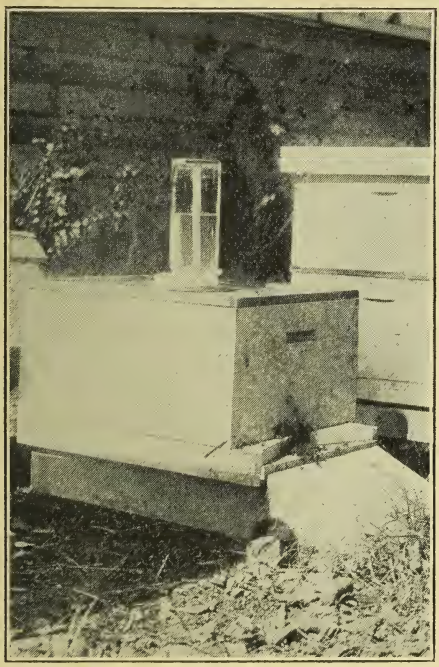


FIG. 17.—BEES NEED WATER.

This hive took down 20 pounds of water during the spring brood rearing season.

available. No comparison could be made on honey yields, because none of the colonies were able to gather a normal surplus due to the peculiar conditions under which the experiment station is forced to operate its educational apiary in the city at distances so remote from nectar-bearing fields.

Water for Bees in the Spring. Bees use considerable amounts of water in the spring during brood rearing. It has

been suggested by some beekeepers that if this water was available in the hive, the bees would not go out during cold weather and become numbed and lost as they are known to do. Last spring in a series of experiments by the Economic Entomology Department measurements were made from April 1 to May 31.

Water was fed by means of graduated flasks covered with a double thickness of cheese cloth, which were then inverted over the hives so that the bees could take the liquid through the cheese cloth. On five colonies pure water only was available to the bees; on three a flask of water and one of a 2 to 100 salt solution were placed to see whether or not the bees would take the salt water in preference to plain water. The amount of liquids taken varied considerably, but the largest amount of water used by one colony was 4.62 gallons for the two months period, while the colony fed sugar syrup and water at the same time carried down 5.3 gallons of sugar syrup and 4.7 gallons of water. When water and a salt solution were given to the bees, both water and salt water were taken down, but the salt solution only in small quantities. No noticeable difference was observed upon the flight of the bees between those which were given water and those which were kept in the apiary.

POTATO LEAF HOPPER CAUSES HOPPERBURN

The potato leaf hopper is one of the most important pests of the potato in the United States. Not only does it suck the juice from the plants so that the foliage turns yellow and the leaves curl and wither, but a diseased condition, hopperburn, is in some manner produced, which causes the foliage to blacken and die.

Why such a condition should follow the raids of the leaf hopper is not well understood, but the indications are that a toxin or possibly a disease is transmitted through the feeding punctures of the leaf hopper. Hopperburn begins with a slight yellowing, usually at the leaf tip, and later the leaf turns brown, curls upward, and withers. The disease spreads from the tip or margin toward the midrib of the leaf but spreads more slowly toward the base. During periods of hot dry weather hopperburn spreads rapidly and whole fields of early potatoes may be killed in a week.

Previously it has been demonstrated by J. E. Dudley (Economic Entomology) that spraying bordeaux mixture upon both top and under side of the leaves will control the leaf hopper and the following hopperburn. A high pressure (150 pounds at least) is used in applying the spray to cover the

Large hibernacages used in hopperburn experiments

FIG. 18.—LEAF HOPPER CARRIES HOPPERBURN

Two plants of Rural New Yorker potatoes caged. Plant on left kept free from leaf hoppers, shows no hopperburn; plant on right infested with leaf hoppers, nearly dead from hopperburn.

leaves with a very fine mist. While these practices have given excellent results, in 1921 three types of experiments were conducted by Mr. Dudley to determine more of the potato leaf hopper control; namely, the effect of planting dates upon the appearance of leaf hoppers, the severity of hopperburn and yields, the effect of none, one, two, and three sprayings upon the yield of potatoes, and selection of seed tubers from vines resistant to hopperburn.

While the results during this season were hampered decidedly by the hot dry weather, nevertheless the two early varieties secured a good start by the middle of June, and had over twice the foliage as the same varieties planted two weeks later. The yield was considerably greater than it could have been with late planting in such a season. The leaf hoppers and hopperburn appeared on the potatoes as follows:

Triumphs	Leaf hoppers June 6	Hopperburn June 13
Early Ohios	Leaf hoppers June 8	Hopperburn June 13
Green Mountains	Leaf hoppers June 13	Hopperburn June 20
Rurals	Leaf hoppers June 13	Hopperburn June 25

Part of each plot was left untreated until hopperburn threatened to become severe. Thus the Triumph plot had to be treated on June 24, and even with frequent treatments from that time on the plants went down with hopperburn quite rapidly. Parts of the other three plots were not treated all summer and yet were not seriously affected by hopperburn until well into August. This was quite different from previous observations, for in past seasons unsprayed potato patches and fields were seen to succumb to hopperburn during hot dry weather within two weeks' time. However, despite the absence of the usual hopperburn ravages, yields were found to be much greater for treated rows than for untreated ones.

Four varieties—Triumphs, Early Ohios, Green Mountains and Rurals—were planted in a field and divided into four equal parts. One part was sprayed three times with bordeaux mixture 4-4-50 and lead arsenate 1½-50; one quarter was sprayed twice; one quarter once; and the last quarter was left unsprayed. Here, again, the experiment could not give exceptional results, for the Triumphs were practically dead, the Early Ohios were yellow and dying, and the Rurals were not growing rapidly on August 17, although the yields were slightly larger on the plots sprayed two and three times.

The potato leaf hopper is particularly dangerous, because it is followed by the hopperburn. Caged potatoes on which no leaf hoppers occurred developed no hopperburn. Caged potatoes into which a few hoppers gained entrance developed a slight amount of burn, while potatoes infected with a large number of hoppers became badly diseased, some of them dying.

Furthermore, in a muskmelon field which was being examined off-colored leaves were found in the middle of several hills. When further examined, they showed clear-cut symptoms of hopperburn, and large numbers of the leaf hopper adults and nymphs appeared on the under side of the leaves. The burn was found only on the hills infested with the hoppers, thus showing that another commercial crop is susceptible to the hopperburn and that muskmelons must also be protected.

Nicotine Dusts Employed Against Insects

Recently a method has been devised for using nicotine sulphate in a dust carrier. Experiments were conducted by John E. Dudley, Jr., (Economic Entomology, coöperating with U. S. D. A.) regarding the control of nine insects: striped and twelve-spotted cucumber beetles, eggs and larvae of the Colorado potato beetle, the two common cabbage worms, the melon aphid, squash bug, potato leaf hopper, and onion thrips. Nicotine sulphate combined with rock lime, 4 per cent and 6 per cent nicotine sulphate content, was used and a new combination, nicotine-bordeaux dust, was prepared at the laboratory by spraying nicotine sulphate evenly on trays of powdered monohydrated copper sulphate and lime, which is essentially uncombined bordeaux, a product sold by one of the insecticide companies. When sprayed with the nicotine, this product heated up, partially turned to bordeaux, and resulted in a very fine dry powder, which was used at two strengths—4 per cent and 6 per cent nicotine-sulphate content. While the nicotine-lime lost strength rapidly when exposed to the air, often falling off 60 per cent in killing power after an exposure of six days, the nicotine-bordeaux under similar conditions of humidity proved more stable and lost only 10 per cent in killing power.

Cucumber Beetle. Nicotine-bordeaux proved most satisfactory for the control of this insect—in the insectary nicotine-lime killed from 80 per cent to 100 per cent of the beetles treated, in the field cages only 63 per cent, while the nicotine-bordeaux killed 100 per cent and 93 per cent respectively. In the field, however, both dusts proved unsatisfactory until a large, specially-made, canvas cone lowered to the ground over each plant was employed. This made it possible to hit a large number of the elusive beetles; yet again the nicotine-

lime killed only 15 per cent while the new spray destroyed 60 per cent.

Colorado Potato Beetle. A large number of potato beetle egg masses were dusted with nicotine-lime 4 per cent. Of the lot only 25 per cent hatched, while 75 per cent of the untreated hatched. When the larvae in the third, fourth, and fifth stages were dusted with nicotine-lime, 90 per cent were killed.

Cabbage Worms. Difficulty was encountered in driving the dust to these feeders, for the worms work deep in the head and under protecting leaves. Tests showed, however, that with nicotine-lime 4 per cent only 60 per cent of the worms were killed, nicotine-bordeaux killing 78 per cent.

Melon Aphid. A field of cucumbers heavily infested with aphids was dusted with the nicotine-bordeaux, a cone being employed with the dust pipe from the blower entering at the base instead of at the top. This allowed the dust to be directed against the under surface of the leaves and practically every aphid was killed.

Squash Bug. Again nicotine-lime proved satisfactory, while nicotine-bordeaux used against the young in various stages killed 90 per cent in the insectary; and, when the operations were conducted in the field, an equally high percentage was found dead four hours after dusting.

Potato Leaf Hopper. A row of large potato vines heavily infested with adults and young of the potato leaf hopper was dusted with nicotine-lime 4 per cent and nicotine-bordeaux. Hundreds of the insects fell on canvas laid along the row and all were dead a few hours later, both dusts proving equally effective. The dusts were further applied to infested bean plants by use of a cone; and, although the curled leaves offered protection to the leaf hoppers, 92 per cent of the insects were killed. Nicotine-bordeaux used in large potato plots entirely freed the vines of leaf hoppers in a short time.

Onion Thrips. Both dusts proved effective against this insect. Plots selected which contained approximately 20,000 thrips each were cleaned up, and only one per cent living thrips were found.

Conclusions

Given a higher nicotine content and improved methods of application, such as a machine throwing a dust cloud, it is believed that in the nicotine dusts we have a new type of insecticide which promises to be of considerable value against many chewing and sucking insects. It is not proposed, however, that these dusts should replace the arsenicals against such insects as the Colorado potato beetle and cabbage worms. Like all contact insecticides the dust must hit and cover the insects treated. Against the cucumber beetles these dusts are far more effective when the adults are hit while in flight than when dusted at rest. Against many sucking insects the dusts, especially nicotine-bordeaux, give promise of offering a control equal to that of the best sprays.

FIG. 19.—DUSTING CUCUMBERS FOR THE STRIPED CUCUMBER BEETLE

Nicotine-bordeaux is effective when the cone is kept over the plant for thirty seconds.

How Far Does Cucumber Beetle Fly?

In order to gain a better understanding of the migrations and concentrations of the cucumber beetle during the spring

and fall, and to help plant pathologists who are interested in the transmission of cucumber mosaic, experiments were conducted to determine the distance beetles fly. Different lots, a total of 8,890 beetles, were colored by hand, blue, violet, green, black, and red. The insects were then released in eight different places, and an inspection of the surrounding country made in an effort to pick them up. Twenty-eight were recovered at distances of from 300 yards to nearly a mile from the point of liberation, and fourteen were recovered a half-mile or more from the starting point. Generally it was observed that the insects, once they rise in a moderate breeze, fly or are carried considerable distances, taking the direction of the prevailing wind.

THE PRODUCER NEEDS ECONOMICS

Many people still think that it is possible to secure costs of production with a reasonable profit on what they have to sell. The course of the last year has demonstrated the fallacy of this theory when applied to any particular product at any given time. In the long run, of course, no man can continue indefinitely in business or in the production of any commodity unless he can make a reasonable profit in the conduct of his business. But while this long-time principle obtains in the disposal of any given commodity at any particular time, no single individual is able to stem the trend of the market and control its operations. It made no difference to the corn-belt farmer this last year what his costs of production were in raising a bushel of corn. The phenomenal crop with its surplus bushels carried the price to such low levels that no single farmer could expect to secure his cost of production, let alone any profit thereon.

Nevertheless, it is important for farmers to know beyond all question what are the actual costs of production of their important agricultural products. Generally speaking, such costs are not determined by any adequate cost accounting method, and, therefore, the farmers know only in a very general way what these figures are. It is, therefore, incumbent upon the Experiment Station to make such economic studies as will give a basis for answering this problem and thus enable the producers to introduce more business-like methods in their affairs.

COST OF MILK PRODUCTION

During the year 1920 the cost of milk production study by S. W. Mendum and H. Keller (Agricultural Economics) was confined to units of feed required, units of feed consumed, and milk produced. Groups from five counties, Sheboygan, Columbia, Milwaukee, Ozaukee, and Marathon, sent in reports from which the results were obtained. These results were compared with similar information obtained from 120

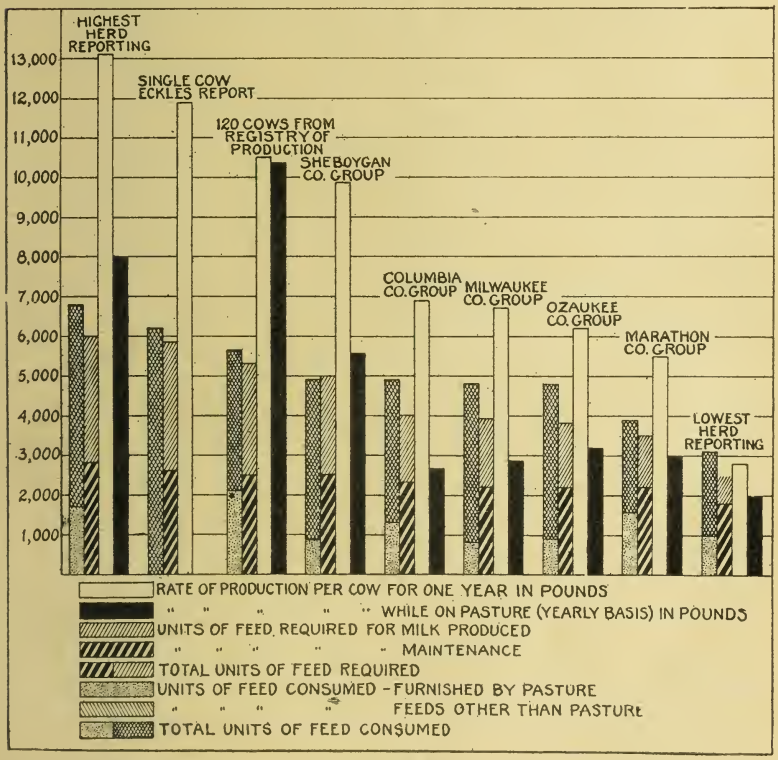


FIG. 20.—A COMPARISON OF THE RELATIVE EFFICIENCY OF COWS

cows picked at random from the Register of Production and the data C. H. Eckles gathered while studying an individual cow. These data are shown in graphic form in Fig. 19.

The relationship between feed required and milk produced is quite evident, for the units of feed required for maintenance remain fairly constant and are largely determined by

the weight of the cows. Any variation shown is due to the different breeds of cattle that are being used in the different counties of the state. However, a direct relation exists between units of feed required for milk and the amount required for producing the milk. Every pound of milk produced requires a certain amount of energy above maintenance, as a prerequisite, and this energy is furnished by the feed. Thus as milk production increases, the absolute number of units of feed required for each pound of milk does not change.

Of course there is a limit to the amount of milk any cow will produce. All feed consumed will not necessarily go toward maintenance and milk. When a cow's capacity production is reached, all extra feed consumed above what is needed for milk and maintenance goes into fat or is wasted. An examination of the chart shows that practically every group overfed the cows. But in each case the amount was small and would not materially affect the feed cost in the production of milk. The difference in feed consumed and feed required may be accounted for in part by errors in reporting data. More care and judgment exercised in feeding might eliminate the rest, but in all cases the amount of overfeeding is slight. It is hard to determine just what significance pasture had. In most cases the poorer herds received the greater amount of pasture with the exception of the Register of Production cows. The data for the Register of Production cows were obtained during a year when pasture was very good. The other information was obtained during 1920 when pastures were affected by lack of water for several months. Also the farmers with the poorer herds—the Marathon group particularly—had a considerable amount of pasture at their disposal and felt obliged to use it. There is no justification for assuming that the quality of the herd is in any way related to the pasture fed.

In 1921 the study has been confined to a single group of farmers, all members of the Cedar Grove Cow Testing Association, who with the help of their tester, Herbert Molter, are supplying the data for the study. The relationships in this study deal with the actual amounts of feed and labor utilized, their market values, and the price received for the milk. As the study is unfinished at the present, little can be said about it, but the intention is to show the actual difference between

price paid to produce the milk and price received, and also to show the amount of home grown feeds, marketed through the milk, and the amount of work the farmer has been supplied with through the medium of his milk business.

Progress Report on Wool Marketing Investigation

Abundant reasons why wool marketing in the past has been unsatisfactory and why a system of federated local and district farmers' wool pools should better past conditions by the establishment and maintenance of a national coöperative wool sales organization are tentative conclusions reached in an extensive study of wool marketing by T. Macklin and L. P. Gabbard (Agricultural Economics).

Two methods of marketing wool are in use at the present time according to this investigation. The less efficient, that of the private ragman who buys without grading and at a single price for all wool, has been employed in handling the product; and consequently dissatisfactions have developed over a period of years. As a result experiments were organized by farmers themselves during the past two years and are being continued by them for the 1921 wool clip. Naturally, a successful outgrowth from these experiments would upset the marketing machinery which previously handled the wool clip. That there should be opposition to any change is to be expected. But in this particular case there is no justification for opposition to farmers' plans to comprehensively market wool. The very fact that there is such wide-spread opposition is proof of the resistance which inefficient marketing agencies and methods put up against the introduction of more efficient methods or even agencies.

To the average farmer, wool is an almost insignificant source of income, for, being a sideline issue on most farms, the farmers have had but small quantities to market. They have had to devote their attention to other matters so much that it has not been worth the while to improve an unsystematic and expensive method of marketing wool.

But at last the farmers have found a way to stimulate improvement by their own efforts, for the very failure of private marketing concerns to build up an inexpensive, comprehensive wool marketing system has obliged the farmers to try to make improvements themselves. This they could attempt to do only by actually doing the marketing themselves, but in

order to establish long needed improvements which many years ago were introduced into the more important marketing methods, farmers need facts. These were obtained, and indicated wherein the old method was weak and expensive and just how it could be improved. The outstanding facts are:

(1) Wool is a sideline production on most farms and as a rule brings in a very small fraction of farm income.

(2) Being a sideline, wool does not constitute a very large volume of business either in quantity or value for the single community or even county.

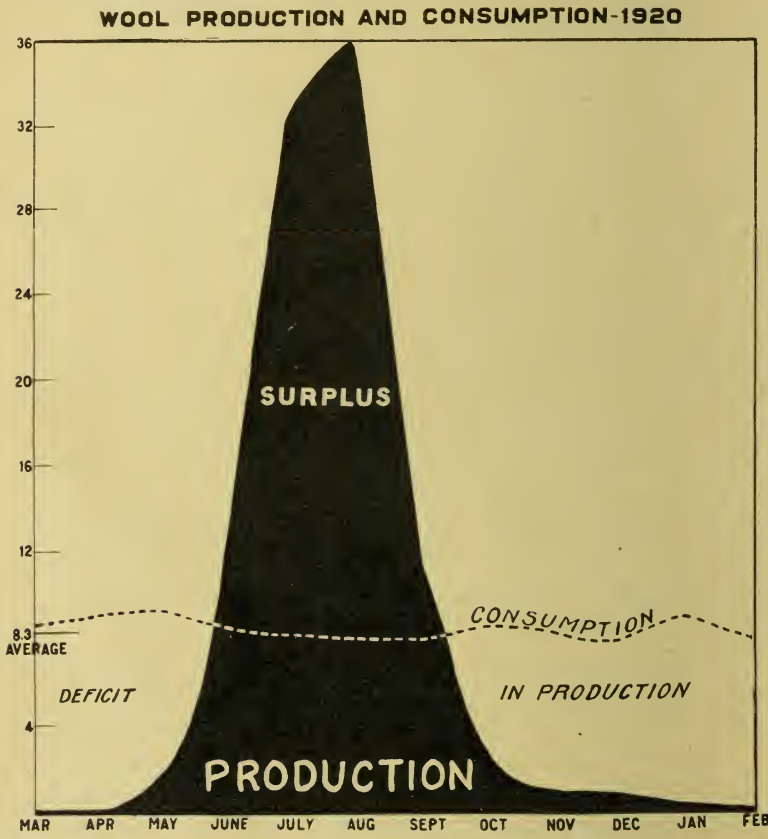


FIG. 21.—WOOL SURPLUS DUE TO IRREGULARITY OF PRODUCTION AS COMPARED TO CONSUMPTION BY THE MILLS

During June, July and August over 70% of the wool moves onto the market but during the same period only 25% of it is used.

(3) Because of the small volume of wool to be marketed at a shipping point, no middleman can afford to become expert as a local wool dealer. Consequently he rarely knows wool

grades, has unreliable information as to the real value of wool that he handles, and therefore has to play safe by paying the minimum prices that farmers will accept. Besides, his costs were excessive on account of the small volume handled and the lack of facilities for proper handling.

(4) These evils, inherent in a small business, constitute the problem which farmers can eliminate by pooling their wool. But just as the private middleman had to finance the buying of wool, when he did the marketing, so also the farmer must now finance the marketing of wool when he proposes to do the marketing himself, either by waiting for his money until the wool is sold or by paying interest to the banks and borrowing the money until the wool is paid for. Will the farmer do one or the other of these two things? If he will not, he thereby refuses to do what he can to establish the most efficient kind of a wool marketing method. If the farmer fails to create efficient coöperative wool marketing, private agencies may systematize wool marketing, but that they will seems unlikely from the present competitive conditions or past experience.

It is, therefore, only reasonable to suppose that substantial improvement is to be gained by actual organization of the farmers to establish marketing enterprises functioning in their behalf. Information thus far obtained by the wool investigation demonstrates the need for increased efficiency in moving wool from farms to woolen mills.

The Agricultural Neighborhood

Upon the constructive organization of community life depends much of the development in rural interests. Various causes determine the size of the so-called rural neighborhood and community; and in a survey conducted by J. H. Kolb (Agricultural Economics) various comparisons were made, such as relationship between neighborhood groups and of these groups to schools, to church, to trade areas, to nationality settlements, and to farmers' organizations. Differing tendencies are responsible for the origin of these groups, yet changes are continually being introduced in their work and their relationship among themselves. In spite of the fact that many of the groups have changed, they must be recognized in any plan of rural organization as a means of utilizing the natural differences between such groups of people.

Since the primary group cannot render all services needed even by their own people, such as education, merchandising, religion, communication, social life and organization, it is altogether necessary that they federate together and join with the village and city groups to form larger community units. This will encourage not only an interchange between city and country, but it will be directly advantageous in bringing together those people from the outside to become a part of the larger, more active community life.

DRAINAGE DISTRICTS STUDIED

To ascertain the quality of drainage which has resulted from the outlet ditches already installed, studies have been made in the Portage County, Clark County, Dancy, Little Yellow, Cutler and Remington Drainage Districts by E. R. Jones and O. R. Zeasman (Agricultural Engineering). The work was done in coöperation with the United States Bureau of Drainage Investigations.

The depth and condition of the ditches, the height of the water table in the soil between the ditches and the general availability of these lands for settlement on the basis of drainage, were investigated because these data are of special value to the prospective owner before he locates on lands of this character. In the Portage County District there is ample drainage between ditches a mile apart where peat about two feet deep lies on sand, and the top of the water in the ditch is 4 feet below the top of the sand. During the drouth of 1921, timothy and alsike suffered somewhat except where the water was held up during June and July by a dam in a ditch carrying considerable water. Excellent crops of corn and sugar beets resulted without subirrigation, particularly on the deeper beds of peat that are more drouth resistant. On the clay-bottom lands of the Cutler project tile will be needed to complete the drainage.

Settlers are making a success on 80-acre farms in these districts by cultivating for the first year or two only such portions as have good drainage during the early spring, and pasturing the rest until they are able to drain and fertilize properly. Peat lands should be rolled with a heavy roller after seeding. Timothy and alsike require less drainage than corn and are profitable crops on marsh lands (if properly handled)

whose drainage is only fair, thus providing a hay crop for the marsh-farmer's stock during the first year or two or producing a cash return if sold.

Cement Tile on Acid Peat. Acid peat soils disintegrate ordinary cement tile, and it has not been proved that it is safe to lay even the best cement tile in acid peat. Although some manufacturers are now making a cement tile which is on a par with shale and hard burned clay tile for clay sub-soils, as yet they are not recommended for peat or sand, and the previous investigations on this subject have yet to be disproved.

Marsh Plow Development. Further research work has been done by F. W. Duffee (Agricultural Engineering) on the development of an improved marsh plow. By using a larger coulter, a heavier frame, a stronger wheel, and a landslide longer and higher, a plow has been devised which works exceedingly well on marshes. It will go through almost any amount of trash and sod without clogging; it turns the furrow directly upside down and practically completely covers the trash, leaving the furrow slices lying flat in condition for working the seed bed.

Tractor Motor Lubrication and Kerosene Fuel

Efforts have been made by Mr. Duffee using one brand of lubricating oil to determine the lasting qualities of the oil when burning kerosene. This oil had an initial viscosity of 540 seconds at 100° F. as measured, and at the end of 15 hours running the viscosity had dropped to an average of 200 seconds for two tests, and the oil had to be changed. The greatest drop in viscosity occurred during the first two and one-half hours.

It was found important to warm up the motor well before shifting from gasoline to kerosene. By burning the high test gasoline for a half hour at the beginning, no material advantage was obtained over merely warming up with common low test gasoline. Different motors will, of course, obtain different results; in some cases oil will last twice as long, the principal reasons being the amount of oil in the crank case and the efficiency of the carburetor. This experiment, however, demonstrates the importance of changing the oil frequently when burning kerosene.

BRUSH PLOWING

In the clearing of "wild" or unsubdued land, it is necessary to remove the slash, logs, and stumps as quickly as possible, so the unproductive or idle acres may be set to work to produce crops that will support the owner and his family. The settler is generally short of funds but has a surplus of his labor, which he is able to turn into capital by clearing his own land.

In some portions of the state the land has only a few stumps to an acre and the second growth of hardwood trees has not become larger than three or four inches in diameter. There it has been found possible, according to investigations by John Swenehart and A. C. Fiedler (Agricultural Engineering), to use large tractors and breaking plows to turn under not only the smaller brush but even trees up to three inches in diameter. Naturally a plan to use a large tractor and plowing outfit is only adaptable where a large colonization company is operating on a tract so located that the distance from one farm to another is not too great or where a contractor can be secured who is in position to undertake this work. The colonization company is interested in the rapid reclamation of the land, for they can receive their money only when the settlers are able to pay them out of what the redeemed land is able to produce.

Studies must be made of the effect of such a practice on the land as well as the effect of such a practice on the new settler. Will it tend to reduce his feeling of responsibility for immediate action? Will it be possible to instill in the new farmer a great amount of energy by arranging to plow as soon as he has brushed the land? Observations along these lines are being made to determine in general whether the practice will be desirable.

The question of the most economical power unit is one which cannot yet be answered. If considerable quantities of large brush are to be turned under, then, undoubtedly, a fairly large tractor will have to be used. Because of the many different conditions, it will probably be impossible to specify the type of tractor which will be most desirable; for, while a wheel type tractor works well under one set of conditions, the caterpillar works better under others. On the other hand, if the

land can be brushed before plowing, a number of horses may be used to give the same drawbar pull of a tractor. Such charges on the tractor as interest, depreciation, repairs, as well as the ordinarily considered maintenance charges must be considered. With horses, charges will include feed, housing, possible injury and consequent veterinary service as well as other items not only when the teams are working but when they are idle. All such factors will need to be considered before a definite procedure may be recommended.

Frank Conrath of Rusk County, situated in a district where conditions are favorable for plowing under brush, used a 15-27 tractor and a well-known grub breaker. With this plow he found the clearance between the beam and land so small that the brush would accumulate and throw the plow out of the ground and also that it was very difficult to remove this clogged material. To eliminate the difficulty, he selected a peculiar shaped tree and out of this timber made a beam which increased the clearance from about 16 inches to about 25 inches. Most of the plows used have been 20 to 24-inch cut. Several of the larger plow manufacturing companies have also been working to develop a plow with larger clearance, and otherwise particularly adapted to plowing under large brush, both on cut-over land and marsh land. During the season of 1922, careful investigations will be made on the general practicability of brush plowing.

Picric Acid for Land Clearing

Over twelve million pounds of picric acid left over from the World War were available for land clearing if it could be used. The picric acid was stored containing approximately 10 per cent moisture, which made it impossible to explode the material. The powdery nature of the dry picric acid made the dust hazard such that cartridging on a commercial basis was impossible. Investigations were carried on to find out how the material could be prepared to eliminate the dust hazard and at the same time retain the explosive property. Various percentages of water and oil were tried with the result that a 2 per cent moisture content was found to allay the dust and, at the same time, the resulting material could be detonated with a number 8 cap.

Complete investigations were then made by Mr. Swenehart as to the effectiveness of picric acid in the field. It was found to be much stronger for stump blasting than any of the ordinary dynamites used. Cartridges made with 5.5 to 6 ounces were approximately equivalent in effective strength to 8-ounce cartridges of 20 or 40 per cent dynamite. The action of picric acid was found to be more shattering than low-grade dynamite, but it was found that this property would not interfere with its effective use. The picric acid is not affected by temperature, does not freeze, and therefore requires no thawing; it is more resistant to moisture than dynamite containing ammonium nitrate or similar hygroscopic substances; and it does not deteriorate in storage when kept dry. The cost of all items of preparation and distribution, including drying, cartridging, cartage, freight, and other expenses, is about 40 per cent of the prevailing prices for equivalent working strength in dynamites. The picric acid is more insensitive than dynamite, but this property can be overcome in field work by using a number 8 blasting cap.

Picric acid is very effective in boulder blasting where its shattering effect is desirable. It is not sensitive enough to be used for propagated ditch blasting. Picric acid is practically non-poisonous, and no ill effects are felt from its use in field operations. Large quantities of carbon monoxide gas (CO) as well as other gases are given off from the explosion; but, when this explosion is in the open air, the gases escape readily. Moist picric acid stains the skin a lemon-yellow color, which is not readily removed but wears off in a few days without harmful physiological effects. Picric acid, therefore, can be said to be a non-freezing, non-toxic explosive for land clearing work.

As the cost of manufacturing picric acid is considerably more than the cost of manufacture of commercial dynamite; therefore the use of picric acid will be limited by the supply of left-over war materials; and, when these are consumed, picric acid will probably not be used as a land clearing explosive.

POWER REQUIREMENTS FOR STUMP PULLING

Stump removing machinery up to the present time has been designed and built largely by guess work, no available data on pounds of pull required being known. In the investigation

by Mr. Swenehart, a 5,000 pound dynamometer was equipped with a set of levers to permit pulls up to approximately 50,000 pounds. While the investigations along this line are not yet completed, much interesting and valuable data have been secured.

The pull required for stumps, of course, varies with the size of the stump, its age, kind of soil, and many other conditions. It is easy to pull a stump so large that its ultimate disposal is impossible from a practical and economical standpoint. With a team as the most common and economical power unit on a large majority of upper Wisconsin farms, the size of pull seems to depend on the capacity to move the pulled stump. Therefore, it seems preferable to use sufficient dynamite to make the size of the piece pulled small enough to be handled by power equivalent to that of a team and team equipment. It was found that the capacity of a team was about equivalent to the capacity of a three-quarter-inch cable on ordinary capstan or drum type of stump pullers. Pulls up to perhaps 20,000 pounds can be safely made with three-quarter-inch cable, but the cable is broken with pulls of 23,000 to 25,000 pounds. It was found also that under most conditions the pieces pulled by a 20,000 pound pull were as large as could be economically handled and piled.

The cable used was standard plow steel cable, 6 strands of 19 wires around a hemp center. This cable is listed with a breaking strength of approximately 23 tons by manufacturers. It is as large a cable as seems desirable to use in a stump pulling operation under Wisconsin conditions. Larger cables are less flexible and less easily handled. Pieces of stump which require a pull of 10,000 to 18,000 pounds to remove, require about 10 or 15 per cent of this pull to skid them for piling. In other words, a pull of 15,000 pounds to remove a stump could be changed to a pull of perhaps 1,200 to 1,800 pounds with extra speed for skidding.

A tabulation of 100 pulls under different soil conditions indicates that most pulls ranged from 10,300 pounds to 20,000 pounds. Above 20,000 pounds will pull pieces of stump larger than a team can ordinarily handle. Cables break after a few of these high pulls. The stumps were white pine having been cut from 20 to 40 years. The different soils were sand, silt loams, and clay. Absolutely no relation could be established

between pulls and size of stump. This information should be particlarly valuable in designing land clearing tools, machinery and equipment. It should point the way for more practical development in stump handling outfits.

WHICH PLANTS FEED BEST ON PHOSPHATE AND POTASSIUM

Crops grown on different soils may thrive or not according to their ability to feed on minerals. Mr. E. Truog (Soils) has continued his work this year, finding that some plants feed much more strongly than others on rock phosphate and the insoluble minerals of potassium. Some plants like buckwheat feed strongly on rock phosphate but poorly on the insoluble minerals of potassium, while other plants like sweet clover feed strongly on both.

In order to explain this, pot experiments were conducted in the greenhouse. In some of these experiments the phosphorus was supplied as rock phosphate and the potassium as feldspar; in others the phosphorus and potassium were supplied in dilute solutions. It was found that the plants with very acid sap are able to get the phosphorus from dilute solutions much better than those with a less acid or nearly neutral sap, while in the case of potassium the reverse was true. Thus, plants with a slightly acid or nearly neutral sap were able to get their potassium from much more dilute solutions than those with a strongly acid sap. When the plant uses the potassium for building compounds in the leaves, stems, or stalks, it must be taken out of solution from the plant sap. It is much easier to remove a basic element like potassium from a slightly acid solution than from a strongly acid one, while in the case of an acid element like phosphorus, it is easier to remove it from a strongly acid solution than from a less acid one. Feldspar is only slightly soluble in the soil solution; and only those plants such as sweet clover that are able to get their potassium from very dilute solutions, i. e., with a slightly acid sap, are able to secure an adequate supply from such a source.

Rock phosphate has been applied in many cases, and it has been found that to feed on this material the plant must have either a strongly acid sap or a high calcium content; for if the calcium content of the plant is high, the solubility of the rock phosphate near the plant roots is accordingly high, and

the material becomes available. If the sap is very acid, it is possible for the plant to utilize the phosphorus from a very dilute solution. Accordingly, the ability of the plant to feed on the various mineral ingredients may influence the availability of fertilizers for different crops.

Obtaining the True Soil Solution

Every soil contains a certain amount of water, some in larger quantities than others. However, while some may be relatively soaked, much of the water clings to the fine particles of soil and is called the soil solution. Inasmuch as the soil solution is taken up by plants and serves not only as a source of water but also as the carrier of plant food, it is very important to know the concentration and composition of the soil solution, for upon it actually depends the fertility of the soil. As the plants absorb their food from this, there may be minerals present in the soil which the plant cannot use, and yet at the same time a laboratory analysis might show a high content of the necessary element. To overcome this difficulty, F. W. Parker (Soils)* has studied the displacement method of obtaining the soil solution and has adapted the method used to a limited extent by foreign investigators.

The method consists of packing the soil at the most favorable moisture content in glass percolators and then pouring ethyl alcohol on top of the column. The layer of alcohol is maintained on the soil until displacement is completed. As the alcohol sinks into the soil, it displaces or pushes out the soil solution, which moves downward ahead of the alcohol and finally drops from the bottom of the glass cylinder. Thus there is obtained a perfectly clear solution, free of alcohol, which seems to be the true soil solution. It has further been found that, whether taken from the first part which is displaced, from the middle portion, or from the last part, the concentration of the solution depends only upon the moisture content of the soil, that is, the less the moisture content of the soil, the greater the concentration of the soil solution. This experiment gives the same result for nitrate nitrogen in the soil as that obtained by the usual water extraction method. Furthermore, about 50 per cent of the soil solution can be dis-

* Fellowship given by Soil Improvement Association.

placed in from 24 to 36 hours before the alcohol passes through a suitable soil sample. This method has the advantage that no special apparatus is needed; the operation is simple, and large amounts of solution may be obtained, while other methods generally require complicated apparatus, or else give a very small proportion of the soil solution. By this process, it will be possible to obtain a much better understanding of soil acidity and fertilizer requirements of soil, thus paving the way for a more accurate determination of soil fertility and acidity in the laboratory than has hitherto been possible by the old water extraction method.

SOILS SURVEY MAPS 775 SQUARE MILES

Not only has the soil survey been of great value in the study of erosion, drainage, and the adaptation of land to machinery used in the production of various crops, but it is locating the limestone and is supplying new settlers with accurate information on Wisconsin soils. Twenty-one counties have thus far been completely surveyed, every ten-acre area and sometimes smaller areas being inspected and recorded. In the reconnaissance survey applied to the upper counties and made primarily to assist in the settlement, every forty acres are considered. During the field season of 1921, the coöperative Soil Survey has been continued, the federal government furnishing three men and the state four most of the season. Mr. Geib, supervising the field work, is jointly employed by the state and federal governments.

In addition to mapping the soil types as has been done in the past, the topography is now being indicated under four classes: First, level to gently undulating; second, undulating to gently rolling; third, rolling to hilly; and fourth, very hilly and broken, or broken. Greater attention is also being directed toward locating limestone for agricultural uses, as the grinding of limestone by individuals and groups of farmers is becoming more popular. One small grinder in Green County has produced about 8,000 tons of ground limestone during the past four years. The calcium and magnesium content of samples from different soil types has been determined in a number of cases. These show a wide range in total calcium content but also indicate that the need for additional lime is probably as largely determined by the total calcium content of the

soil as by the amount of acidity. Furthermore, no relation exists between the total lime content and the degree of acidity, making it necessary to determine not only the acidity of the soil but the total calcium content before the lime needs can be definitely determined.

Water-Holding Capacity of Sandy Soils

An inventory of Wisconsin soils shows that approximately six million acres, one-fifth of the total area, are recognized as sandy soils. As population increases and development advances, these soils will be used more and more for the production of food. Very often a farmer finds the water supply the most important factor influencing the productivity of these soils. Accordingly, since 1917 H. W. Stewart (Soils) has been gathering information regarding the utilization of moisture by growing crops.

Three principal types of sandy soils were examined,—medium sand, fine sand, and sandy loam. Soil samples were placed in galvanized iron cylinders 18 inches in diameter and varying in depth from 27 to 78 inches. These cylinders were provided with drainage and sunk to a depth which brought the tops flush with the ground surface. Fertilizers were added to supply the needs of the crops grown in order that the moisture content might be the only limiting factor. Five crops of corn, oats, clover, or soybeans have been taken from the soil.

In the spring of 1921 plots were established on the three classes of soil on farms near Hancock, Wisconsin, in order to continue the work under field conditions. The crops grown were also fertilized to supply the necessary plant food, and from this work the comparison of the different types of sandy soils was made. Average yields in the soil cylinders showed that the sandy loam gave an increase over the sands (medium and fine) of 15.96 bushels of oats, 0.7 of a ton of oat straw (four-year average), 11.82 bushels of corn (1920 crop) and 0.31 of a ton of stover (four-year average), 3.83 bushels for a two-year average of soybeans, and 9.1 of a ton of straw; but in the case of clover a difference of only 0.01 of a ton was shown. These differences in yields indicate: (1) That the sandy loam utilized its moisture more efficiently than the sands, especially in the production of corn, oats, and oat straw;

(2) that sands are not soils adapted to the production of oats; (3) that the utilization of the moisture in the sandy loam was not much better than that of the sands in the production of soybeans, clover, and corn stover; (4) and that sands will supply moisture nearly as well to soybeans as the sand loam, and soybeans are therefore especially well adapted to this lighter soil type.

During 1920 and 1921 the height of the growing corn was measured from time to time at Madison and at Hancock to determine whether or not the effect of soil texture, in its relation to water supply, influenced the height of the plants. In every case plants were higher on the sandy loam than on the medium and fine sand with an average difference over the two-year period of 8.6 inches in favor of the sandy loam. Over five hundred moisture determinations were made during the summer of 1921 of soils on the Hancock plots, which showed: (1) That the sandy loam contained an average moisture content to a depth of 40 inches, twice that contained in the sands; (2) that after June 27 the average moisture content to the same depth was slightly lower in the fine sand than in the medium sand. Much discussion has recently been centered about the depth to which rainfall will penetrate in the different types of soil. On July 27 a rainfall of 0.5 inch was measured as follows:

Rain Penetrates Farthest in Medium Sand (Inches)

	Corn	Oat Stubble
Medium Sand	15.0	9.0
Fine Sand	5.5	5.5
Sandy Loam	4.0	3.5

This table shows that the coarser texture soils allow the rain to penetrate deeper than do the finer textured types, thereby removing it from the crops. This is further borne out by the fact that the crops such as clover, soybeans, and corn are relatively much better on the coarser types of sandy soil than are those such as oats with root system growing near the surface. Continued observations on this project will be needed before final conclusions should be drawn.

GREEN MANURE AT SPOONER

Green manuring experiments by A. R. Whitson and F. L. Musbach (Soils) were begun in 1914 at this branch station

and no stable manure or commercial fertilizers have been used since the beginning of the trial. In the rotation corn is followed by oats, clover, and potatoes. When corn is grown the rows are planted 2½ feet apart alternating with lupines, soybeans, or serradella in the different plots, the green crop being

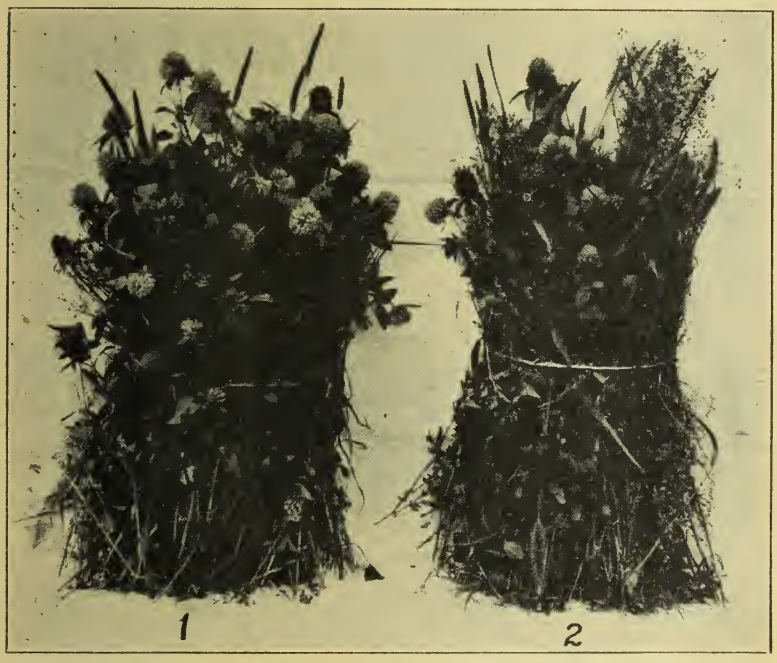


FIG. 22.—CLOVER ON LIGHT SOILS NEEDS MANURE

Bundles taken from equal area. (1) 4.5 tons manure on corn and equal amount on rye; (2) no manure used.

plowed under after the corn is removed. When potatoes are planted, an early variety such as Triumph is used, and, after digging the potatoes, the fields are planted to sand vetch, clover, or rye. These crops are allowed to make the maximum growth in the spring before the ground is plowed for the corn crop, which follows potatoes. On the check plots a higher yield of stover has been obtained because the rows are planted 2½ feet apart and are not alternated with any green manure crop but in all other cases the organic matter and nitrogen have increased the yield of oats nearly 10 bushels an acre (8-year average), over the check plots at 26 bushels; potatoes 8 bushels (8-year average), over the check plots of 100 bushels;

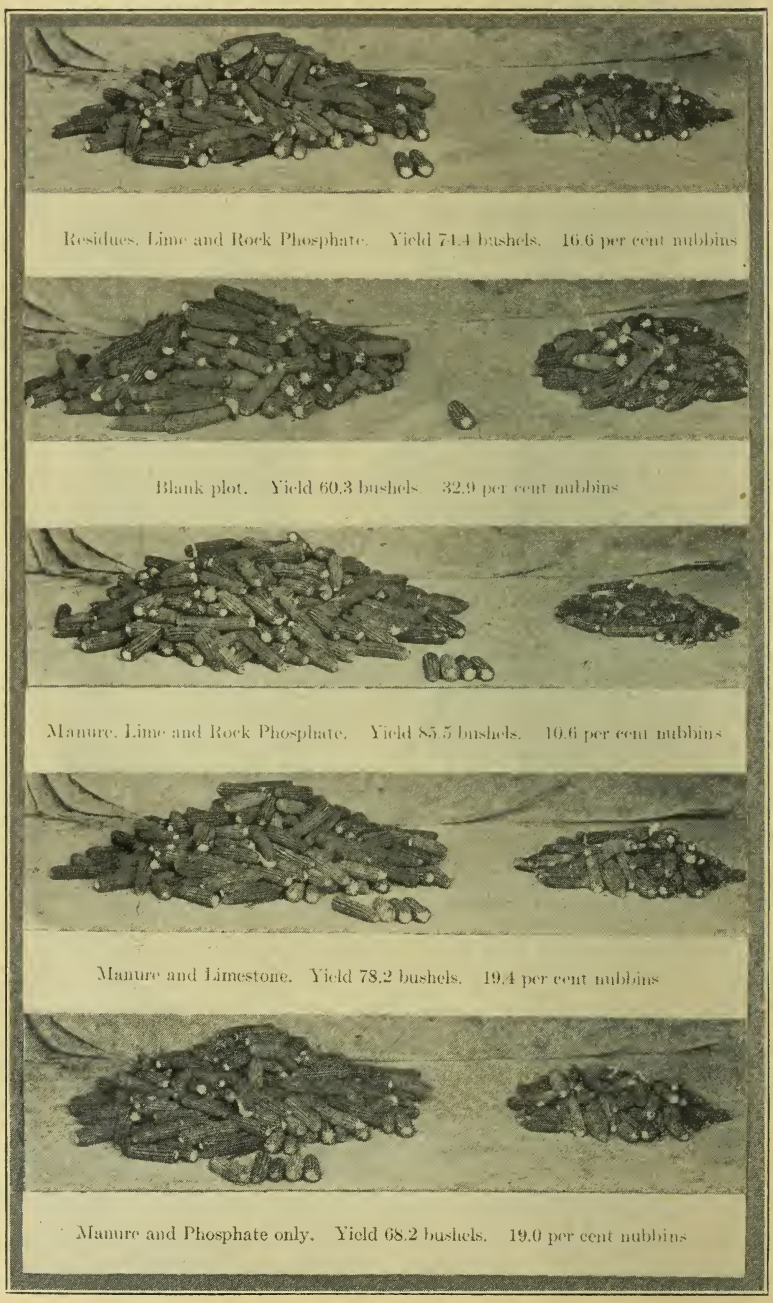


FIG. 23.—MANURE, LIME, AND ROCK PHOSPHATE GROW BETTER CORN AT MARSHFIELD

and clover a quarter ton (7-year average), or 2 tons an acre on the green-manure plots. This method of rotation and soiling offers an opportunity to maintain soil fertility when the barnyard manure is not plentiful and when humus is needed.

Fertilizer Work on Light Soil at Spooner

Fertilizer work was further conducted by Mr. Musbach and Mr. Whitson on light sand soils at Spooner Station in a rotation of corn, oats, and clover. The fertilizers were applied with the corn crop, ground limestone being broadcasted with the oats and clover seeding. Here the use of fertilizers supplementing stable manure did not raise the yield to any considerable extent in the case of corn or in the other crops grown in the rotation. Manure alone has apparently been sufficient to supply the plant food necessary to produce the crops grown. This may be due to the fact that six years prior to the time the experiment was started a three-year rotation was practiced on the fields, and during that time one-third of the entire field each year was devoted to legume crops, such as soybeans, clover, and sand vetch, which were plowed under. Thus, only two out of three crops were removed from the field, and the manure applied has been particularly rich in plant food requirements.

Potato Work. Plots for fertilization of potatoes using stable manure supplemented by soluble phosphates and potash, and crop residues with complete fertilizers were begun in 1914. The rotation is oats followed by clover and then by potatoes, and the fertilizers are all applied to the potato crop.

Here it appears that the highest yields were obtained on the three plots receiving mineral fertilizers in addition to stable manure, although the difference was not great. The results further show that since clover has always occupied the land one year out of every three, together with the fact that the manure used comes from a herd receiving considerable concentrates in their rations, it is hardly necessary to supply fertilizing constituents from other sources. Such a rotation is sufficient to maintain the fertility of the soil.

Plots which received no stable manure but merely clover clippings plus a high grade complete fertilizer yielded 220

bushels of potatoes per acre; those with manure 233 bushels an acre, while with manure and 375 pounds of acid phosphate, 244 bushels an acre were obtained.

It does not appear that on this particular field the available plant food has been the limiting factor in crop production. The field is one of the best on the farm, and it is probable that the effects of the rotation together with the quality of manure used had made it possible to maintain the crop yields at a rather high level.

ROTATIONS FOR SUPERIOR SANDY LOAM

Two five-year rotations have been laid out, one consisting of half corn and half potatoes, fall rye, oats, clover, and mixed hay, the other of half rutabagas and half potatoes, spring wheat, oats, clover and mixed hay. Twelve tons of manure were applied to the cultivated crops, and half of the plots in each case received 250 pounds of acid phosphate in addition to the manure while the small grain crop following, wheat in one case—rye in the other, also received an application of 250 pounds of soluble phosphate.

The rotations were begun in 1919 but show, in only two years' results, the advantage of supplementing manure with acid phosphate. With the corn and potatoes, fall rye, oats, clover, and mixed hay rotation, the results were as follows:

Crops	Manure	Manure and Acid Phosphate
Oats	32.6 bu.	39.0 bu.
Rye	28.7 bu.	31.1 bu.
Corn	48.6 bu.	61.2 bu.
Potatoes	190.7 bu.	186.9 bu.

With rutabagas and potatoes, spring wheat, oats, clover and mixed hay, the rotation yielded:

Crops	Manure	Manure and Acid Phosphate
Oats	31.06 bu.	40.54 bu.
Wheat	4.99 bu.	6.69 bu.
Potatoes	210.37 bu.	205.38 bu.
Rutabagas	10.43 tons	17.33 tons

ASHLAND RED CLAY NEEDS SPECIAL ATTENTION

Last year was one of the best seasons for small grains on the red clay soils as represented by the Ashland Station for both temperature and rainfall were ideal for a big crop. The rotation used on the test plots is corn, wheat, oats and clover. On

the 26 fertilizer plots conducted by Mr. Musbach even the oats yielded 70 bushels an acre. An addition of ten tons of manure and 250 pounds of acid phosphate increased the yield to 88 bushels an acre, while the application of ten tons of manure with 500 pounds of rock phosphate averaged 79 bushels. By adding 10 tons of manure alone, the yield was increased to 78 bushels an acre. While this experiment must be continued further, the results show improvement which may be obtained by using fertilizer.

Treatment of Colby Silt Loam at the Marshfield Station

Two questions have been asked many times: (1) Which is better, rock phosphate or acid phosphate? (2) Shall we use ground limestone or gypsum? Mr. Musbach and Mr. Whitson have now finished a four-year series of experiments using a rotation of clover, corn, barley and oats. Last year when winter killing damaged the clover, soybeans were substituted. This rotation has had a very favorable effect, for even on the untreated plots the yield has been good—corn 45 bushels, oats 57 bushels, and clover hay 1¾ tons an acre. Although barley has been a relatively low yielder under all conditions, it proved much better than wheat, which has failed on this type of soil.

The advantage of phosphate has been shown, for while practically 33 per cent of the corn on the untreated plots consisted of nubbins, less than one-half that amount of nubbins was found in the corn grown with phosphate treatment. Rock phosphate, generally, is giving results equal to acid phosphate, although it must be borne in mind that the heavier application of the rock phosphate means higher freight and distribution charges, and that at the present time the descending price of acid phosphate and the new treble super-phosphate are particularly advantageous.

Lime has generally shown itself beneficial although it must be recognized that lime is not always necessary on even the very acid Colby soil for clover or other crops until the land has been under cultivation for a considerable number of years. On the other hand, careful work continued over a long number of years has shown that gypsum or phosphate is of no benefit, while liming has shown a profitable increase with corn of 7.4 bushels, oats 6.1 bushels, and clover hay of 492 pounds. The 1921

trials showed not only a higher yield but a better quality of corn. An increase in yield was secured of better than 17 bushels in favor of the lime plot, while of the limed corn 10.6 per cent was found to be nubbins, and on the unlimed land the average amount of nubbins was 19 per cent. Generally, the use of stable manure and limestone has shown good increase in the crops for four and five-year averages. Manure, supplemented by either rock phosphate or acid phosphate with limestone, has served to push the yield of oats 2 bushels, of corn 3.9 bushels, and of clover 175 pounds an acre ahead of the untreated crop. Potash, on the contrary, shows no increases when used to supplement manure and phosphates.

BENEFIT OF UNDER-DRAINAGE ON COLBY SILT LOAMS

The effects of tile on ground that has not ample surface drainage has been studied by the use of test plots. Mr. Whitson and Mr. Musbach have found that the tile on this type of soil should be placed not farther than 3 rods apart. In case of cultivated crops the increase when closer to the tile has been most marked. Corn 4 rods from the tile yielded 59 bushels an acre for a three-year average; while corn 1 rod from the tile yielded 64 bushels an acre. When 2 and 3 rods from the tile the corn yield was 62.6 bushels an acre. While potatoes 4 rods from the tile yielded 154 bushels, 1 rod from the tile they yielded 192 bushels, with 172 bushels and 162 bushels the yields at 2 and 3 rods distances. Alfalfa showed an advantage of 415 pounds an acre of the 1-rod-from-the-tile over the 4-rods-from-the-tile crop, while barley showed a difference of only 2 bushels an acre for that close to the tile over that 4 rods from it.

DOES DEEP TILLAGE PAY?

Whether to use deep tilling machines or deep plowing has caused much discussion in previous years. These results have been obtained by Mr. Musbach at the Marshfield Station as a result of from five to nine years' test:

1. Deep plowing and subsoiling have not been found profitable.
2. Corn on a five-year average has given the best yields on spring plowed land followed by ordinary fall plowing to a depth of 6 to 7 inches.

3. Deep tilling has given the lowest yields.
4. With oats, nine-year tests have shown a trifle higher yield on spring plowed than on ordinary fall plowed land; likewise deep tilling gave the lowest yield. In clover and timothy the results are variable.

Colby silt loam is a rather heavy soil, typical of the Marshfield area and is not like the Miami silt loam in the southern part of Wisconsin. At Ashland, subsoiling has increased the yield for the barley crop 3 bushels an acre over fall plowed land or spring plowed land, although with corn, clover, and clover and timothy the yield was not materially increased. Other deep tillage treatments, however, did not increase the yield and are not recommended, while the extra cost of subsoiling does not pay for itself. Fall plowing to a depth of 6 inches has shown a better yield in corn while with hay crops of clover and timothy spring plowing seems to have advantage over other methods.

Coddington Branch Station Works With Marsh Soil

The Coddington Experimental Plots are located on the Buena Vista marsh, which lies in Portage and Waushara Counties. The ground has been under plow for three seasons. Other marshes with similar drainage, subsoil, and climatic conditions are found in Adams, Juneau, Wood, Monroe and Jackson Counties. These marshes for the most part consist of a rather raw peat with occasional flats of black sand. Where the soil has been cultivated for five to ten years, the peat verges toward muck. The depth of peat or muck varies from nothing on the sand ridges to six feet in other parts.

Two problems face the farmers on this type of soil after drainage ditches have been established—danger from frost and a shortage of mineral elements in the soil. Accordingly the experiments, conducted by Mr. Whitson and A. R. Albert (Soils) at the Coddington Station, are ascertaining what crops are sufficiently frost resistant or short seasoned to insure some measure of harvest. Data are also being gathered on the various manurial treatments in order to best employ commercial and other manures. In 1921 crops grown at the station were corn, oats, rye, sugar beets, table beets, potatoes, sunflowers, flax, soybeans, alfalfa, sweet clover and a timothy and alsike mixture. Corn, grain and hay suffered severely from frosts on

June 4 and 5, but the corn made a good recovery where fertilized or manured, and as there were no fall frosts until September 11, it matured well. Some hay and grain recovered, while others grew up to weeds.

The unfertilized plots of corn yielded 27 bushels an acre, but with 150 pounds of muriate of potash and 400 pounds of acid-phosphate they yielded 46 bushels; with 150 pounds of muriate of potash and 800 pounds rock phosphate, 48 bushels were produced; with 150 pounds of muriate of potash and 400 pounds acid phosphate, and lime the yield was 44 bushels; while with 8 tons of manure the corn yield was 51 bushels, and with 8 tons of manure supplemented by 400 pounds of acid phosphate the yield was 54 bushels an acre.

Oats did not recover from the June frost, and accordingly the crop was cut for hay, yielding about one-half ton an acre. Unfertilized rye yielded 4.75 bushels an acre. Potatoes planted on unfertilized ground on one of the sand flats were practically a failure due to the exceedingly hot summer. Flax matured a crop of seed, but drouth prevented the development of fiber of any value, although the seed yield on variously treated plots was 438 pounds an acre and the straw 4,428 pounds. Soybeans on the marsh were cut for hay, and alfalfa and sweet clover sown May 31 and June 8, respectively, with no lime or manurial treatment produced an excellent stand but showed no nodules on the roots. The timothy and alsike mixture was frosted so badly that weeds grew thick and heavy.

The sugar beets planted were not fertilized, and the crop was harvested for stock feed; but table beets on fertilized plots proved very promising. In the unfertilized plots the table beets yielded 4,750 pounds an acre, but with 300 pounds muriate of potash and 400 pounds acid phosphate, they returned 8,660 pounds an acre, almost double the yield of the unfertilized plots. The beets were marketed at $12 a ton, thus giving a return of $23.46 on an expenditure of $17 for fertilizers.

In estimating the value of fertilizers, however, the residual effect thereof on succeeding crops and the effect of the 1921 drouth must be considered. While the rainfall in 1920 during the growing months of April, May, June, July and August was 18.1 inches, in 1921 only 12.3 inches of rain fell during the same

time. Undoubtedly, had there been more rainfall the benefits of fertilizers and manures would have been greater, but it is also certain that the danger of early fall frosts would have been increased. The Coddington Branch Station offers an opportunity for the first hand study of a particular type of marsh soil. Experiments will be continued not only to devise crops for state marsh reclamation projects but tillage methods and weed control through rotation and cultivation together with the beneficial effects gained from fertilization will be considered in the future investigations.

Alfalfa, the Soil Improver

Although history informs us that alfalfa was grown in Italy more than two thousand years ago, many American farmers still look upon it as a comparatively new crop. In Wisconsin the acreage is, however, gradually increasing, and government crop reports show that the state has now approximately 121,000 acres of alfalfa. Because of its great value as a feed for dairy cattle in combination with silage, it is welcomed whole-heartedly by Wisconsin farmers.

Alfalfa gives an average yield of a ton more an acre than standard hay crops, clover and timothy; and where it can be grown it is helping to solve many of the economic problems of the present day and to supply the farmer with home grown rations for feeding his dairy cattle. In spite of the fact that in the alfalfa areas of the west, hay can be bought for from $5 to $8 a ton in the stack, baling, handling and freight costs make the price of this hay f. o. b. Wisconsin range from $18 to $25 a ton. High transportation costs serve as a protective tariff on home grown alfalfa; whereas other farm crops such as small grains and corn have been governed by competition with the nearby states. Alfalfa thus remains almost free from competition and proves itself a very profitable hay crop.

With or Without Timothy. Twenty-four plots were seeded in 1920 under the supervision of L. F. Graber and Nels T. Nelson (Agronomy) with three varieties, Grimm, Common and imported Turkestan, each variety being sown with and without a mixture of one-fourth timothy. Four cutting stages were selected, namely, bud stage, half bloom, full bloom and seed

pod. It was found that the alfalfa-timothy mixture for all cutting stages out-yielded alfalfa alone by an increase of nearly one ton per acre or 25 per cent, the increase occurring entirely during the first cutting. This may be accounted for in the fact that the alfalfa was but one year old, and with favorable winters age will increase the yielding capacity while tending to decrease the effect of the timothy.

Two cuttings of alfalfa alone in full bloom stage gave the same yield (4.4 tons an acre) as three cuttings in tenth bloom although the quality of hay was somewhat inferior.

Two cuttings of the alfalfa-timothy mixture in full bloom gave 0.4 tons an acre more hay than three cuttings in the tenth bloom stage.

Cut during the seed stage (alfalfa alone), the two crops of rather coarse, woody, or stemmy hay yielded 0.5 tons less than two crops taken in the full bloom stage.

The seed stage with alfalfa-timothy mixture produced two crops of coarse hay with timothy more abundant in the first crop than with any of the earlier cutting stages.

ALFALFA SEED PRODUCTION

While Grimm alfalfa has with a few exceptions proven superior in its hardiness to the average common strain, the price of the seed has been such of late to make it almost prohibitive to many Wisconsin farmers. With a falling market for clover seed, soybeans, and practically all field crops, Grimm is still being held at from 40 to 50 cents a pound. More and more it is appearing that Wisconsin must grow her own seed. The past year's results have been gratifying.

It is estimated that our state produced during the last season not less than 1,000 bushels of alfalfa seed—this being largely confined to the eastern counties. Yields of two bushels an acre were not uncommon, and in one instance five bushels were reported. The summer drought seems to have stimulated seed formation, and, while we may not always have weather conditions so favorable, it should be borne in mind that with red clover our yields of seed average only about two bushels an acre and in some seasons have been a failure.

An effort will be made to develop a hardy strain of alfalfa which will tend to produce seed in our humid climate.

Soybeans for Light Soils

Soybean plants were grown as early as 1898 on experimental plots of the Station Farm. One of the first successful varieties was the Early Black, and, while it has been pedigreed, other varieties have also been introduced, such as the Manchu, Ito San and Black Eyebrow all of which have been raised among the farmers of the state. The methods of harvesting, threshing, cutting for hay and silage have been worked out to such an extent experimentally that this legume can now be handled to advantage.

Especially is the soybean adapted as an emergency hay crop for farmers who lost their clover seeding by winter killing. After the failure of the clover is discovered ample time remains to put in soybeans, for they will readily come into cutting stage for hay within the ninety day period. With yields of two tons an acre of good hay, which compares favorably with cutting of red clover, soybeans are practically a sure crop; and even on poor sandy lands that have grown soybeans previously by the proper innoculation of the seed, an exceedingly good growth can be secured at first attempt. One grower, asked why the field remained so clean with soybeans, replied, "The soil is too poor to raise weeds."

In Portage County soybeans are so popular that many individual farmers have a total of 100 acres or more apiece. Wisconsin not only grows all the seed needed in our state for planting at the present time but supplies the Dakotas, Minnesota and the northern Michigan peninsula with a large portion of seed for their farms. This has developed a very satisfactory seed business among many farmers of the state.

Breeding Increases Yields. Soybeans have been gradually improving in the state, and while it was once deemed impossible to raise them here effectively because they were a late maturing plant, breeding methods have produced early varieties adaptable to Wisconsin conditions. The acreage has increased from 4,500 in 1919 to 8,000 in 1920.

Net results obtained at Spooner Branch Station by E. J. Delwiche (Agronomy) prove the worth of the breeding work. Compared with the parent strain as seed producers, the pedigreed strains of Manchuria showed that, while the date of

maturity was not changed, the yield has been increased from 19 per cent to 96 per cent. All varieties ripened about September 19 except the Mandarin Pedigree, which was mature on August 30. The Mandarin has an erect habit (38 inches high), a high-podding character, and an early maturity thus making it adaptable to a wide range of conditions.

Tests at Marshfield and Spooner Branch Stations, in spite of the unusually long and hot season, again showed that not only do the early types produce more seed than the late kinds but they are equal to them as producers of hay. Of the twenty-four varieties planted in duplicate plots at Marshfield the following failed to ripen seed and were killed by frost October 4: Ebony, Wilson, Sable, Ohio Manchu, Mammoth

FIG. 24.—SOIL TOO POOR TO RAISE WEEDS GROWS SOYBEANS

When this soybean grower was asked how he maintained such clean fields, he replied, "The soil is too poor to raise weeds."

Yellow, Elton, Hollybrook, Virginia, and Medium Early Green. The Medium Early Green and the Hollybrook both yielded 2,880 pounds of air-dried hay, but the average of the later maturing was only 2,500 pounds an acre.

SUDAN GRASS AND SUDAN-SOYBEAN MIXTURE

Sudan grass has proved admirably adapted to late seeding, which permits it to be used not only as an emergency hay crop but also as a crop planted after fallowing to eradicate quack grass. Although the best time for planting sudan is during the period from corn planting up to the middle of June,

yet in 1921 sudan seeded as late as July was nearly headed out and fit to make into hay by the latter part of August, according to G. B. Mortimer (Agronomy). Two years ago seeding delayed until the first week in July gave equally good results. Sudan grass in a normal sand makes an excellent smother crop on account of its rapid growth, the density of its fibrous root system, and the shade which it gives to the surface of the soil from the beginning.

Quack grass has been successfully eradicated by it at the Station Farm in two infested fields. Trials with 20-pound and 30-pound rates of seeding broadcast show no material gain in yield for heavier rate, the average being 3 tons an acre of air-dried hay. With good seed the 20-pound or 25-pound rate of seeding seems to give the best results with broadcast or drill.

Sudan and Soybeans a Good Combination. In 1920 it was satisfactorily proved that soybeans and sudan grew very well when planted together; and during 1921 different rates of seeding were used to determine the proper mixture. The rate of sudan grass used was 10 pounds an acre and soybeans 1.5 bushels an acre, with the varieties, Medium Early Green, Ito San, Manchu, and Wisconsin Early Black. The average total yield of the two plots of the Medium Early Green was 4.1 tons of cured hay an acre, of the Manchu 4.3 tons, Ito San 4.6 tons, and Early Black 3.5 tons. The average percentages of soybeans were 17.5 per cent, 23 per cent, 29 per cent and 42 per cent respectively. The highest average in the combination was with the Early Black variety, where, due to the advanced stage of maturity, nearly one-half the total weight of air-dried hay was soybeans. The early varieties seem preferable, for they mature at nearly the same time the sudan is cut for hay, thus giving a higher relative yield of soybeans.

The average percentage of soybean hay for the four trials, being approximately 25 per cent, means an increase in total protein per 100 pounds of dry roughage from 8.96 pounds in sudan hay alone to 10.75 pounds in sudan-soybean hay, an increase of 19.9 per cent—the increase in pounds of protein per 100 pounds being 1.79. The average digestible protein content per 100 pounds of dry matter in sudan grass hay, as reported by the Federal Department, is 3.89 pounds; and allowing an

average of 25 per cent of the total weight of hay in the mixture with soybeans, the digestible protein content of the hay would be increased from that figure to 4.7 pounds in the mixed hay or an increase of 20.8 per cent in digestible protein.

FIG. 25.—SOYBEANS AND SUDAN GRASS EXCELLENT EMERGENCY HAY

Sudan grass, 10 pounds per acre with Ito San soybeans, 1.5 bushels per acre. The yield of air-cured hay was over 4 tons per acre. A mixture of this kind increases by one-fifth the digestible protein.

Yields obtained from seeding the soybeans in the mixtures at one, one and one-half, and two bushel rates per acre show that one and one-half bushels is best. Coöperators throughout the state, who testify to the estimated results obtained with soybeans and sudan especially upon lighter soils, have also found this rate most satisfactory. Soybeans grow better when thoroughly inoculated, while the sudan grass does not attain quite as large a growth, hence increasing still more the percentage of digestible protein.

CANADIAN YELLOW SWEET CLOVER A SUCCESS

Two years ago R. A. Moore (Agronomy) secured from Professor Lennox, formerly of the Guelph Experiment Station,

Canada, a sample of Canadian Albotrea sweet clover. This sample was sown on the Station Farm in the spring of 1920 with oats as a nurse crop. The plants came up readily and would have afforded excellent pasture in the fall of 1920; but the crop was not pastured in order to determine its value in 1921 as a hay and feed producer. The Albotrea yellow blossom sweet clover is much finer in stem and more leafy than the biennial white blossom sweet clover. Consequently it makes a much finer grade of hay and, as it is earlier in maturing, can be cut at a time when the season is most favorable for haymaking. Notwithstanding the loss incurred from hulling with an ordinary threshing machine, the Albotrea yielded twelve bushels an acre this year.

This yellow blossom sweet clover promises to become one of Wisconsin's staple forage crops. It has a decided advantage over the Hubam sweet clover both in abundance of growth and ability to grow on wide variations of soils. Moreover, it is not necessary to grow it under cultivated conditions as is done with the Hubam sweet clover, for it will catch readily when sown in the same way as the common red clover. This enables people in sections of the state where it is now almost an impossibility to grow the red clovers to put in a leguminous clover for hay and seed. Seed yields are more than double the amount of biennial clover seed, and yet it can be grown on soil where it is impossible to get a catch of the biennial white sweet clover. Seed which has thus far been cleaned and scarified will be sent out the coming year to cooperators in various parts of the state for conclusive tests of the advantages of this promising crop.

Trials With Hubam Sweet Clover

For several years extravagant statements of the merits of the annual white blossom sweet clover called Hubam have come from various sources. This clover has been studied for three years at the Experiment Station, more extensively in 1921 than before, but up to the present time there is nothing to warrant continuing the growth of the Hubam clover.

All field tests were failures, and weeds grew so abundantly the clover did not make even good hay, according to R. A. Moore (Agronomy Department). One plot grown under gar-

den conditions and cultivated yielded five bushels of seed per acre, although cultivation under ordinary farm conditions is impractical. As a general field crop, these results show that Hubam is a failure; and growers should be warned against purchasing the high-priced seed. As a honey producing plant it will probably find favor among bee men, as it is a later flowering plant than the biennial sweet clover.

KUDZU MAY PROVE NEW FORAGE PLANT

Kudzu (Pueraria thunbergiana) is a leguminous vine introduced from Japan. It has been grown in the United States since 1876, but only recently has attracted attention as a plant of economic importance. While the Japanese grow it on hillsides and use it for pasture, they also make the stems into grass cloth. The roots, which are rich in starch, are sometimes used for human food, and occasionally hay is made from the vine. Kudzu is relatively hardy and thrives best in parts of the eastern United States, where the climate is moist and warm; but it will live through the winters as far north as Nova Scotia.

Under field conditions Kudzu produces long prostrate branches, having many joints from which leaf petioles grow up, each bearing three leaves similar to those of the common bean. When these joints come in contact with the ground, roots start and new plants are thus propagated. As the Kudzu plant produces only a few poorly germinating seeds, it is the usual custom to start a field by planting cuttings or young plants started from cuttings.

Horses and cows eat the green leaves readily. Hay is palatable to the animals, although a very rank growth in the largest vines usually makes it tough for the cows to eat. According to the United States Department of Agriculture, however, "chemical analysis indicates that Kudzu is very nutritious, being comparable to alfalfa and clover."

Experiments conducted in 1921 by H. W. Albertz proved very interesting. The plants obtained from Charles E. Leach, Cherokee Farms, Monticello, Florida, were set in rows 4 feet apart and 4 feet apart in the rows. The vines grew to

20 feet in length with the joints from 10 to 15 inches long and the length of the leaves from 6 to 12 inches. Although the older stems were found to be tough, the leaves of the younger shoots were tender; and when the second growth arrived, it produced much finer vines and more leaves. Vines with the leaves were fed to horses, cattle, and hogs and seemed

FIG. 26.—KUDZU VINE

This vigorous vine may prove a valuable forage crop for Wisconsin—especially in the newly-cleared areas.

to be relished by all of them. But it is yet necessary to determine whether the plants will withstand Wisconsin winters, and it is proposed to determine its worth as a forage plant in the cut-over lands of upper Wisconsin.

Sunflowers for Silage

During recent years much attention has been attracted to the use of sunflowers as a new silage crop, and in some states sunflowers have been hailed as the solution to the corn problem. Investigations conducted in Wisconsin by E. D. Holden (Agronomy) during 1919, 1920 and 1921 show that sunflowers can be

grown successfully under almost any climatic and soil conditions to be found in the state and that they yield a larger tonnage of green material than any other silage crop. However, one of the most important questions yet remains unsolved, that is, the value of sunflower silage as a feed for dairy cows.

The 1920 crop of sunflowers grown on the University Marsh was cut August 29 and September 1 when the plants averaged one-third in bloom. The lower leaves of the plants were dried up and brown, yet the crop was only slightly attacked by rust, and the freshly cut silage contained 83 per cent moisture. By cutting and ensiling the crop early and at a comparatively immature stage, it was planned to avoid if possible the tough, woody material frequently found in silage made from more mature plants. During the winter the silo was opened and some cows started on a part ration of the silage preliminary to a feeding test. Sunflower silage was somewhat more acid than corn silage from the same field and contained a considerable amount of fibrous woody material. Although in a number of weeks' feeding the cows were induced to clean up more of the sunflower silage, they did not take to it readily but picked out the corn in the mixture.

Sunflowers grown at the Ashland Branch Station under the direction of E. J. Delwiche (Agronomy) during 1920 were put up in two lots, one from a cutting when but few of the plants were in bloom, the other in full bloom. The silage from the later cutting proved to be unpalatable and of poor quality, and the cows ate it sparingly and fell off in milk production. Silage from the early cutting, however, was eaten readily by the cattle and with no decrease in milk flow.

Various reports from farmers throughout the state have shown experiences quite similar to those at the Experiment Station. Some are discouraged in the use of sunflowers while others praise it as being one of the best crops they have ever grown.

Some prevailing opinions throughout the state seem to be:

1. Sunflowers should be cut during the budding or early blossoming stage, that is, early enough to prevent the stalks from becoming woody.

FIG. 27.—PROPER PLANTING NECESSARY FOR BEST SILAGE

2. Mixed silage of corn and sunflowers often gives excellent results.
3. The crop is better when the corn and sunflowers are grown separately than when they are both grown together.
4. Generally where corn can be grown to good advantage as a silage crop, it does not pay to raise sunflowers.
5. In the upper part of the state sunflowers are proving very advantageous as a silage crop.

Sunflower Blight and Time of Cutting. During the last three seasons both in our own fields and in those of many growers the lower leaves of the sunflowers planted for silage began to dry up and turn brown somewhat before or during the blossoming period, and the withering of the leaves continued up the stalks until the crop was cut. This condition is worse in a dry season than in a wet one and worse on high dry soil than on low moist land. Under drouth conditions late plantings are particularly affected by this blight; in thick plantings the leaves begin to wither earlier and the loss of leaves is greater than in thinner planting. If the leaves are attacked by rust the withering is hastened and is more extensive. Much of the evil effect of this blight can be prevented by early cutting, for the preponderance of poor silage comes from sunflowers cut when quite mature, while most of the good silage is made by ensiling during the early blossoming stage. Exceptions occur when the soil is rich and moist, but experience shows that the early cutting is desirable if the leaves are to be saved for palatable silage. Sunflowers planted at corn planting time or before may be ready the first half of August, while if they are planted in the middle of June or later, they may be cut during the first part of September.

Thickness of planting. Inasmuch as the condition of the stalk and the freshness of the leaves greatly influence the quality of silage, the thickness of planting has considerable influence. The best results have been obtained when the plants do not average closer than 6 inches apart in the drilled row. In the tests no difference in the condition of leaves could be seen between planting 6 inches and 10 inches apart in the row. Further, by cutting the sunflowers as short as possible with the silage cutter, the hard woody pieces of stalk which may otherwise appear, can often be avoided.

Corn and Sunflowers for Mixed Silage

During 1919 and 1920 several fields planted to mixtures of corn and sunflowers were observed, but the results were rather unfavorable. Where the sunflowers formed a large part of the

FIG. 28.—SUNFLOWERS AND CORN GROWN FOR SILAGE

Sunflowers and corn, two rows of each alternating, for mixed silage, Marshfield, August 13.

crop, the corn was badly handicapped because of the rank growth and dense shade. The stalks became spindling and the ears small; many stalks did not bear any ears. Where corn was the major part of the crops and made a normal growth, the sunflowers were so few that the benefit of the greater yield of the sunflowers seemed largely lost, for the increase in yield hardly offset the extra labor required to handle the top-heavy sunflowers. Furthermore, the sunflowers arrived at the best stage for ensiling earlier than the corn so that if the crop was cut when the sunflowers were ripe, the corn was immature, while if cutting was put off until the corn was sufficiently mature, the sunflowers became woody and tough.

At the Marshfield Branch Station corn and sunflowers drilled together in rows in three different proportions gave the following results:

All sunflowers	11.5	tons	per acre
Corn and sunflowers, planted 1 to 1 by volume	11.5	"	"
Corn and sunflowers, planted 2 to 1 by volume	12.3	"	"
Corn and sunflowers, planted 3 to 1 by volume	10.7	"	"

FIG. 29.—SUNFLOWERS EFFECTIVE SMOTHER CROP

Sunflowers broadcast at the rate of 45 pounds an acre, for a weed smother crop at Marshfield Branch Station.

Although the quality of the silage has not yet been tested the highest yield was noticeably from the plot where 2 of corn to 1 of sunflower seed was used in planting.

By following the practice of some growers who plant the sunflowers and corn separately, then mix them in ensiling, some of the disadvantages of growing the two together have been overcome. Another method, observed in two fields, was to plant two rows of each, corn and sunflowers, alternately. This was done by filling one hopper of the corn planter with corn and the other with sunflower seed. The corn in these fields made a normal growth, not suffering from the competition with the sunflowers as when the two were planted together in the row. By this method the bundles of corn and sunflowers can be thrown onto the same wagon from one side and the other, making it possible to secure a very even mixture in the silo. Some growers have planted corn and sunflowers together even where corn can be grown, so that if the corn should be killed by an early frost, the sunflowers will still make good silage.

Sunflowers as an Aid in Weed Control

As a cultivated crop, sunflowers are very effective in controlling weeds, because of the cultivation in the early part of the season and the dense growth made by the crop in the middle and latter part. To increase the effectiveness of such control, some growers fallow the ground in the spring and early summer, planting the sunflowers, late along the first to the middle of June. At the Marshfield Branch Station a field was fallowed in the spring and early summer, sunflower seed being broadcasted at the rate of 45 pounds per acre early in June. The sunflowers grew exceedingly dense, and inspection in July and August showed the ground to be absolutely bare of other vegetation, proving the sunflowers to be a most effective smother crop. The yield of this broadcasted field was 8.25 tons per acre of green silage material.

Cold Resistant Golden Glow Continues Successful

While it has been possible to breed varieties of corn which will ripen seed in the extreme upper part of Wisconsin, efforts have not been diminished to obtain a corn which will serve for both silage and seed. For several years B. D. Leith (Agronomy) has been testing common Golden Glow corn with

cold resistant corn which he has obtained by germinating in an ice box. He has succeeded in obtaining a corn which can be planted from ten days to two weeks earlier than ordinary corn. Planting in 1921 was made on April 29, and the corn was inspected August 22, when it was found that while all

FIG. 30.—COLD-RESISTANT CORN IN BREEDING ROWS

This corn is selected for hardiness, large amount of forage and earliness. Marinette county is at present a center of production.

the ears of the cold resistant corn were ripe, on the common Golden Glow corn the percentage ranged from 76 per cent to 80 per cent mature ears. In Polk and Marinette Counties cold resistant corn is proving very popular, for, with its large stalk and foliage and its early maturing ability, it is an excellent dual-purpose corn.

High Corn Yields in Upper Wisconsin

Aside from variety testing, the work at Spooner has been to improve the Wisconsin No. 25 (small yellow dent) by getting rid of dwarf and weak stalks and shortening the shank. No. 25 at Spooner yielded 80 bushels per acre and at Marshfield 73 bushels. Planting tests were conducted by putting corn in the ground May 1, 10, 20, and 30. At Spooner the corn planted on May 2 froze almost to the ground on June 4, but it recovered, was ripe on August 22, and after husking time it yielded 77 bushels of shelled corn per acre. Corn planted May 10 was ripe two days later with the same yield; corn planted on May 20 was ripe August 29 and yielded 86 bushels per acre; while corn planted May 31 was ripe on September 6 and yielded 98 bushels an acre. This late date corresponds with the yield from Golden Glow planted eight days earlier. These results seem to indicate that early varieties produce bigger yields if planted late, provided the frost is later in the fall.

Drilling Versus Broadcasting

While the drill has been generally advocated as a grain seeding implement in preference to the broadcaster, many of our best farmers claim the drill is not suitable to their conditions and prefer the broadcaster. Undoubtedly the type of soil enters into this question. It was not possible to carry on a test on different kinds of soil at the Station, but a drilling and broadcasting experiment has been carried on for seven years on the Miami silt loam soil of the test plots.

TABLE II.—DRILLING VERSUS BROADCASTING—AVERAGE YIELDS PER ACRE

	Drilled, 7 year average	Broadcasted, 7 year average
Marquis Spring Wheat, Wis. 50	18.7 bu.	18.6 bu.
Oats, Wis. Ped. 1	57.1 bu.	61.5 bu.
Barley, Wis. Ped. 6	45.6 bu.	46.0 bu.

The results from year to year fluctuated slightly, in some instances the drilling showed a slight advantage and sometimes the broadcasting did. The seven year average shows no advantage of drilling over broadcasting. A three-year test with winter wheat shows no advantage of the drill over the broadcaster if sown before the twenty-second of September. When the broadcaster is used, the ground is often worked

less than where the drill is used. Thus on heavy soils the seed bed must be well worked, and the broadcaster will then give as good results as the drill on clay soils.

FIG. 31.—CAREFUL WORK MAKES WISCONSIN LEADER IN PURE-BRED SEEDS

Pedigreed strains are first tested in small plots. The product of each plot is threshed, weighed, and scaled separately. Machine and rakes are all carefully cleaned to prevent mixtures.

EARLY OATS PROVE BEST IN 1921

In test plots under the supervision of B. D. Leith (Agronomy), the Kherson types of oats ranged from 47 to 57.5 bushels an acre while the medium late varieties ranged from 13 to 41 bushels an acre. Early Kherson oats has an apparent advantage in such a season as that of 1921 where heat and drouth appear early in the season; and in the southern part of Wisconsin the Kherson strains are to be recommended.

Breed to Change Color of Kherson. In order to remove the objectionable yellow color of this oats, crosses were made between the sixty-day, a Kherson type, and the Big Four (Wisconsin Pedigree No. 2) of the medium late white type in 1911. Selections for white color, earliness, and large size have been carried on until Pedigree No. 19 has been produced, which shows up well in yield, is white in color, and is two or three days earlier on an average than Pedigree No. 7.

RYE VERSUS WHEAT OR OATS

Five-year averages at Marshfield, according to Mr. Delwiche, shows a yield of 48.0 bushels an acre for rye and 21.0

bushels for wheat. At the ruling prices for the two grains, this makes rye the most profitable crop to grow in that section of the state. At Ashland the difference in rye and wheat yields is not so great, and wheat is therefore more profitable.

Experiments comparing rye and oats were similarly conducted at Marshfield, Spooner, and Conrath. The five-year average yield of rye was 2,615 pounds or 46.7 bushels an acre, while that of oats was 1,507 pounds or 47.1 bushels, thus giving rye an advantage of over 1,100 pounds. Oats planted after corn in the rotation yielded 777 pounds or 24.3 bushels an acre

FIG. 32.—A FIELD OF WISCONSIN PEDIGREED No. 2 RYE

The Wisconsin Pedigreed No. 2 rye leads in yield. It has averaged 7.7 bushels per acre higher in yield than the Rosen during a four-year average.

as against 1,001 pounds or 31.3 bushels of rye. When planted after rye, the oats produced as well as if planted after corn, and this year the yields were 777 pounds or 24 bushels after corn and 847 pounds or 26.5 bushels after rye.

At Conrath, oats yielded 838 pounds as against 1,024 pounds of rye, while at Spooner the oats were practically a failure, the yield being below 10 bushels an acre and the rye being over 19 bushels. These results show the advantage of rye over oats on the productive loam soil of central Wisconsin.

Where dairying is carried on intensively, rye should be sown after corn and cultivated crops, and then followed by oats, as this method serves both to increase the dry matter and, at the same time to prevent the lodging of oats.

HOME GROWN CLOVER SEED BEST

Clover variety tests initiated in 1920 are still in progress. Results this year show conclusively that imported red clover seed, at least that from regions of mild winters, does not stand Wisconsin winters. The test further demonstrates that red clover, originally imported from Europe but grown in America for a long term, has become acclimated undoubtedly through the survival of the hardiest plants. At Ashland, Marshfield, and Spooner, Italian varieties showing 100 per cent stands in the fall had dropped to 10 per cent in the spring at Ashland, while at the other stations the entire plots had winter-killed. With South Dakota, Ohio, and homegrown seeds the stand in the spring at Ashland and Spooner remained 90 and 95 per cent, respectively, although at Marshfield the stand was only 40 and 45 per cent of that in the fall. Clover seed coming from sections of mild winters should not be planted in Wisconsin.

BREEDING SPRING AND WINTER WHEATS

During the past season, work in breeding spring and winter wheats has been continued at the Branch Stations by Mr. Delwiche with especial reference to M1611, a pedigreed Early Java. At Marshfield this variety yielded 16.5 bushels an acre while Marquis yielded only 6.7 bushels. In the plots at Ashland it was much more resistant to stem rust than other varieties. The clean stems showing no rust were as follows: New Java, 77 per cent; common Early Java, 35 per cent; Marquis, 40 per cent; Fife, 35 per cent; and Durum, 25 per cent. Although this is a very promising spring wheat and out yielded all other wheats tried, at Ashland its total yield per acre was only 11.4 bushels, less than half as much as winter wheats. The new strain M1611 promises to be well adapted to central Wisconsin conditions, but in the Superior region winter wheat is preferred to spring wheat.

* Coöperation, Bureau of Plant Industry, U. S. D. A.

FIG. 33.—PEDIGREED EARLY JAVA RESISTS RUST

The early Java Stock (1) yielded only 9.0 bushels an acre for a five-year average; the new pedigree (2) yielded 16.0 bushels an acre during the same time.

At Ashland the five highest yielding wheats were all hard winter varieties of the bearded type, yielding as follows: Pedigree 11823B, 30.4 bushels; 11837, 29.4 bushels; 11825, 28.9 bushels; 1047, 28.1 bushels; and 408, 26.8 bushels. Extreme hot weather at Marshfield reacted unfavorably, and for the first time the winter wheat yield did not exceed the spring wheat yield.

How Late Shall Winter Wheat be Planted?

It is often impossible to seed winter wheat early in September, due to the general custom in Wisconsin of planting winter wheat on ground from which the silage corn has been removed. Winter wheat is still maintaining higher yields than

spring wheat; and, in a nine-year average, Marquis, the highest yielding spring wheat, gave an average of 23.2 bushels per acre; while the Pedigreed No. 2 Turkey Red wheat yielded 37.2 bushels per acre for the same period, and Pedigree 408 Bacska yielded 35.9 bushels per acre. Seven-year tests have been conducted on time and rate of seeding winter wheat by Mr. Leith; and it seems entirely safe to recommend fall planting of winter wheat in the latitude of Madison as late as the last week in September.

TABLE III—ADVANTAGE OF PLANTING BEFORE OCTOBER 1.

Time of Planting		Bushels
August 20-25	3 year average	32.4
August 27-September 13	4 year average	35.5
September 13-25	7 year average	36.7
September 26-October 10	7 year average	33.3
October 11-21	4 year average	20.6

The effect of various seeding rates has been studied for seven years, and no advantage has been obtained by seeding two bushels rather than one bushel an acre.

Rate of seeding winter wheat (7-year average):

1 bushel	33.6
1½ bushels	32.9
2 bushels	33.9

HEMP REMAINS THE IMPORTANT FIBER CROP FOR WISCONSIN*

As is true with many other industries the depressed economic situation has created a critical situation in the hemp industry. The 1919 crop was moved to good advantage, but of the 1920 crop not over 50 per cent had been sold on October 1, 1921. It was this crop that had previously been purchased on contract from the growers at a price too high to permit the scutch mills to dispose of it at a satisfactory price. Furthermore, domestic hemp has been obliged to compete with foreign fibers, while the prices have been affected by proportionately high transportation rates. At the present time freight rates from Wisconsin points to eastern manufacturing districts are practically as high as the ocean freight rates from

* Coöperation with Office of Fiber Investigations, U. S. D. A.

European ports to the Atlantic seaports. In order to tide the industry along until the country again is normal, new markets and new uses for hemp have been developed, and efforts are being directed toward reducing freight rates and obtaining a tariff on the imported fiber.

Particularly successful have been the efforts to encourage the use of Wisconsin hemp by manufacturers of coarse cordage and rope. While in previous years the thread manufacturers were our principal buyers, the low prices of European flax have practically eliminated that market. A tariff rate of three-fourths of a cent upon imported hemp was inserted in the bill which passed the House of Representatives, but it is not sufficient to properly protect this new industry. When the bill is listed for final consideration efforts will be made to impose a higher rate .

Seed Situation Much Better. Sufficient acreage has been contracted for with the hemp seed growers in Kentucky to satisfy all normal Wisconsin requirements. As a protection, however, breeding work has been carried on with the growing of hemp seed in Wisconsin, and this year several acres of the Ferramington variety have been grown in several parts of the state. The acreage is sufficient to determine whether this variety will prove satisfactory for fiber purposes, and if it proves successful, we shall be in a position to supply abundant seed of a pure strain for the commercial production of the crop. The difficulty in producing our own hemp seed is that our season is ordinarily too short to mature the strains of hemp most suitable for fiber production. It is also a question whether or not a variety can be developed which will yield satisfactory fiber and whether our own farmers can afford to grow hemp seed in competition with the Kentucky grower. Natural conditions in the Kentucky river bottoms lend themselves to the profitable production of hemp seed, and it may be that we had better rely upon Kentucky growers rather than upon seed which may be produced in Wisconsin.

In spite of the development of the unfavorable conditions in connection with crop in 1920, the acreage in 1921 increased. This was due not to the addition of new centers of production but to an increased acreage in the section where the hemp

industry was already established. During 1921 Wisconsin produced three-fourths of the entire hemp fiber of the United States, and the amount grown here during that year was 8,000 acres, more than 1,000 acres over that of the preceding year.

FIG. 34.—FIBRE FLAX SEED PLOTS

While present conditions do not favor growing flax for fiber yet producing fiber-flax seed at six bushels an acre offers possibilities.

With only 400 acres of hemp in Wisconsin in 1915 the acreage in 1921 has increased to 8,000 acres or more than twenty times that of six years ago.

FIBER FLAX SEED GROWING

Fiber flax of good quality can be produced in many sections of Wisconsin, according to experimental work in previous years conducted by Mr. Wright. The suitability of the Buena Vista marsh for fiber flax was investigated during the season of 1921. Part of the plots were on the Branch Station Farm and part on the Bradley Polytechnic Institute property. Tests on the substation were in charge of Mr. Malloy, while the other

tests were in charge of Mr. Nelson. The season was unfavorable, and, as a result, the fiber flax was an unsuccessful crop. When grown on old land, it was necessary to remove the weeds by hand in order to prevent the choking of the flax; although when it was planted on sod land, the flax was comparatively free from weeds. From one year's trial and other available data it appears that fiber flax has not made a showing sufficient to warrant its commercial production on marsh soils. Until the matter has been thoroughly investigated, it is not advisable for any linen company to erect a plant to produce flax fiber in competition with flax of foreign countries.

While present economic conditions do not warrant establishing a commercial fiber flax industry depending upon the present machinery and equipment that is available for handling the crop, a small industry might be developed in the production of improved fiber flax seed.

Fiber Flax Seed. Investigation of fiber flax seed showed that there were no varieties of fiber flax grown upon a commercial scale which could be considered pure, although fiber flax readily lends itself to improvement by selection. Pure strains originally selected by the Federal Office of Fiber Investigations have been tested on the Experiment Station Farm for several years. All strains have been eliminated except one named "Saginaw," which is superior in height, freedom from branching, purity, resistance to lodging, and to disease. A two-acre field in 1921 made a very satisfactory growth and averaged approximately forty inches in height. This was from six inches to a foot higher than that of other strains of fiber flax grown commercially during the same season in other sections of the country, while the yield was six bushels an acre. It appears that seed from such a strain would find a good market, for it is a general custom in nearly all fiber flax growing sections to import new seed after the second or third year; in Ireland all seed is imported, because the fiber plants are harvested before they mature seed. The problem now remains to discover whether the seed of this particular strain will prove satisfactory for commercial fiber flax sections. In addition to the seed, the straw will be a valuable by-product as there is already a market for green flax straw among manufacturers of upholstery, insulating material, and linen rugs.

BREEDING MORE SYRUP INTO SORGHUM

In addition to selecting for visible characters, such as type of plant, freedom from branching, height, maturity, and the like, Mr. Wright has also been selecting and testing plants for the percentage of solids in the juice. It is planned to develop a strain which has a higher percentage of total solids in the juice than that of other strains, thus yielding a higher quantity of syrup.

From seventy individual plants selected and tested for percentage of solids in 1920, twenty were planted in head-to-the-row test, and selections made from these rows were tested in the fall of 1921. Inasmuch as sorghum is considerably cross fertilized in the field, variation in the matter of inheritance was to be expected, although a number of selections produced a progeny which had a uniformly high percentage of solids. Further application of this method to various strains may obtain not only early maturity but a higher yielding sorghum cane as well.

NEW METHOD IN MEASURING SORGHUM SYRUP

The low price of sugar has had a direct effect upon the sorghum industry, for the acreage of sorghum in Wisconsin in 1921 was approximately one-third less than in 1920. During recent years the haphazard method of determining the amount of syrup due each patron has resulted in considerable dissatisfaction; and, in view of this, a simple method was devised by Mr. Wright.

Each mill is equipped with two or three juice vats instead of one. These vats are marked so that by measuring the depth of juice in inches the number of gallons can be readily determined, and each patron given his proper credit. The juice from each lot is then tested with an ordinary Brix hydrometer to show the approximate percentage of solids. From this, 1 to 2 per cent is deducted to allow for waste in handling the juice, spilling, and the like; and the number of gallons of juice is then multiplied by the corrected percentage reading, the result being the approximate number of gallons of syrup each patron should have. This method has proved so satisfactory that a number of mills have adopted it and in each case have been well pleased with the results.

Breeding to Prevent Barley Stripe Disease

Several years ago an inspection of 540 fields of barley showed an average infection from barley stripe of 5.2 per cent, and in some of the fields 40 and 50 per cent with the crop yield reduced accordingly. Working jointly, A. G. Johnson (Plant Pathology) and E. D. Holden (Agronomy) have been experimenting to obtain a resistant strain of barley and to eliminate from barley seed the organism of barley stripe (Helminthosporium gramineum).

Seed for three different plots was treated for three hours in formaldehyde solution in the proportion of one pint of 40 per cent formaldehyde to 30 gallons of water. Plot I was seeded April 7, Plot II early in May, and Plot III June 12. It was anticipated that by planting at different dates it would be possible to secure one plot which would germinate under conditions favorable for the suppression of stripe. These barley plots were segregated from other fields of barley by from 30 to 50 rods. April 7, 1921, was an exceptionally early date and was followed by a snow storm about a week later. Plot II was, accordingly, planted about the optimum barley seeding period, while Plot III was planted very late to see if stripe infection would be suppressed, thereby permitting the stripe-free seed to be obtained.

Contrary to the results of previous seasons, the early planting proved to be stripe-free; the seed obtained from this plot was of fine quality, and throughout the entire season no striped plants could be found. The plot planted at the regular planting period was maturing during the extremely hot summer and was affected not only by stripe but by rust. The late planting, again, while it was badly attacked by rust, showed no striped plants in the plot throughout the season; and inasmuch as the disease winters over only on the seed, it is possible that stripe-free seed may have been obtained in these two plots and may thus form the basis for further experimental work in 1922.

Breeding for Oil in Soybeans

This year the eighth season's crop of soybeans was harvested and further data gathered by Mr. Lindstrom about the

possibility of increasing or decreasing the quality of oil, such as can be used for a drying agent in paint manufacture.

In previous years a high and a low line strain of soybeans have been isolated, and the last report from the chemist shows that the high line strain gives an iodine index number of 134, indicating a fairly high quality of drying oil, linseed oil being approximately 180 on the same basis. The low line analyzes 125. Selection within either the high line or the low line has, however, failed to change the quality of the oil. The reason for the original effect of selection lay in the impurity of the variety at the time the experiment began. This means that once a pure line of soybeans has been bred, it is useless to continue selection for a higher quality of oil. To increase the quality, it is therefore necessary either to cross the different varieties or to continually analyze new strains with the hope of isolating a better producing type.

Is an improvement in the quality of the oil followed by a decrease in the amount of oil in the plant as we continue to select? Five years data on this gives a slight negative correlation, which shows that as the quality is increased the quantity or percentage of oil is very slightly decreased, although the latter is of no practical importance.

MORE WISCONSIN-GROWN SWEET CORN

At present the majority of factories canning sweet corn in Wisconsin obtain their seed from the New England states. Investigation has shown that the sources of this seed and the method used in procuring it are careless and inadequate. In some cases entire lots of seed have given very poor germination. Mr. Holden and Mr. Lindstrom this last year have studied methods of seed selection and seed curing.

Most of the varieties of seed corn now grown in Wisconsin can be improved considerably, and breeding plots at the Experiment Station for the last three years have produced some seed of promising worth from one of the most widely grown varieties. One large seed company has established a seed farm for producing sweet corn in this state; and, accordingly, it will soon be possible for the factories to purchase Wisconsin-grown seed, thus insuring more uniform growth and a better germination throughout.

Due to the fact that a fall of prices in the season of 1920 made it impossible to dispose of the pack at prices even far below the cost of production, a large share of the 1920 pack was held over into the present season. A further consequence of this was that in some sections the acreage was devoted to fancy and higher priced varieties rather than to the larger yielding varieties previously grown. Generally, however, the outlook is improving, and the indications are that next season's acreage and production will be nearly normal.

Breeding Sweet Corn for Canning

Special varieties of sweet corn used for canning purposes in this state, such as Crosby, Early Evergreen, Stowell's Evergreen, Hickox, and Golden Bantam need improvement in the uniformity with which they mature and in quality and yield. Co-operative work done by Mr. Lindstrom and Mr. Holden has shown much improvement. Last season two breeding plots were grown, one containing fifty rows, each row coming from a cross of different varieties. The other plot of sixty rows came from the inbred or self-pollinated ears of the best sixty plants comprising the commercial varieties ordinarily grown in this state.

An unusually striking contrast was noted between these rows, for in the inbred plot considerable variation appeared in height of plant, yield, character of growth, season, and in the presence of poor, abnormal plants. Although some of the rows of this plot were uniformly good, the great majority were poor in height and yield and contained a wide variety of abnormal and defective types. This is conclusive evidence that our best commercial varieties are inherently mixtures of good and poor types of corn.

Experience has shown that a close selection within such varieties is very likely to result eventually in "running out." For this reason the Station is attempting to eliminate the poor and defective types; and the method of close selection or inbreeding followed by crossing of the best remaining types is the only hope, for the poor plants will gradually show their weakness and thereby be eliminated.

In the cross-bred plot of corn, the vigor and uniformity of most of the rows was notable. While the inbred rows of Early

Evergreen averaged five and a half feet in height and the Crosby variety five feet, the Evergreen-Crosby crosses averaged fully eight feet in height, were uniformly very early as both parents had been, the quality was an intermediate between the cross-grained Evergreen and the fine-grained Crosby, and the yield surpassed either parent. The Evergreen-Hickox and Crosby-Hickox crosses were equally vigorous but were nearly a week later, due perhaps to the late strain of Hickox used in making the cross. While the crosses of Golden Bantam with either Evergreen or Crosby did not show as great vigor or yield as the other crosses, they were exceptionally early. The Golden Bantam parent was used in this case, primarily, to introduce quality into the ordinary white sweet corn and thus to make a corn more suitable for canning.

The results of this cross-bred plot show decisively that some of our state-grown strains of sweet corn when crossed give increased vigor and yield. This is especially true of the Crosby- Evergreen (Early and Stowells) and the Evergreen-Hickox crosses, and thus opens up avenues for improvement work. It is not to be expected that the vigor and yield of the crosses made in this way will hold up in succeeding years —at least such is the experience with field corn when the varieties are known to be mixtures such as most of them are. Until we can purify our commercial types by close selection and then cross them, we cannot hope to produce a first class sweet corn. However, the first two years work with sweet corn indicates that good combinations may be isolated from the material at hand.

EXPERIMENTS SHOW INBREEDING EFFECTS

A wide diversity of opinions as to the effects of inbreeding have long been held by both scientists and practical breeders. It is generally admitted that inbreeding is an important influence in "fixing" characters, but it is reputed to accentuate the bad qualities in stock as well as the good. Inbreeding was doubtless an important factor in the origin of all the important breeds of live stock. Many of the early breeders bred from the best regardless of relationship. But such methods often led to "over-refinement" and to physiological deterioration, such as constitutional weakness and lowered fecundity. As a

consequence most breeders today try to follow some middle course, breeding close enough to strengthen "type" but bringing in occasional new "blood" to maintain vigor and fecundity. These methods are often designated as forms of "line breeding."

Inbreeding in its broad sense means a reduction in the possible number of ancestors which an individual may have and accordingly implies relationship among the ancestors. Nevertheless, there may be a high degree of inbreeding in the ancestry of the parents of an individual and the parents themselves be unrelated. Such a mating would be called an "outcross" by the breeder. Thus there are two things concerned in the inbreeding of any individual: (1) the proportion of the actual number of different ancestors to the greatest possible number, and (2) the relationship of the parents. The first means the reduction in the possible number of "blood lines" contributing to the individual, and the second the number of "blood lines" the two parents possess in common.

The essential point is that inbreeding, especially with close relationship of the parents, leads to homogeneity, since it means intermixtures of "bloods" already present and little or nothing new brought in. If two parents contain in their germ plasm all the factors necessary for vigor, high fecundity, and other desirable characteristics, there is no reason why their offspring and later descendants, even with the closest inbreeding should not have all these same good traits, *providing all the offspring could have passed to them the same germ plasm that their parents had.* Different offspring will inherit different combinations of the heritable potentialities of the parents, and hence many will lack in some qualities. In this way desirable, or even necessary, constituents of the germ plasm ("blood") may be lost out. Once lost, there is no way to recover them except by bringing in new "blood" in which they may be present, that is, by an outcross. The unfortunate part is that the outcross may bring in new undesirable characters as well.

Proper selection, then, appears to be the key to successful inbreeding. Individuals combining good strong constitutional vigor with the desired characteristics of the breed in other respects are rare, and the breeder must often choose between

an individual which has desirable breed characteristics but is lacking in vigor, fecundity or the like, and some other more vigorous animal which is not as good in breed points. If he chooses the former, he is apt to lose just those subtle physiological properties necessary for the highest vigor and fecundity. Usually he pursues a middle course.

An experiment was started some years ago at the Wisconsin Experiment Station by L. J. Cole (Genetics) and J. G. Halpin (Poultry Husbandry) to test this point. Breeding was begun in 1912 with a pen of Rhode Island Red fowls. In each succeeding year brother was mated to sisters, selection being based on a purely non-vital character—that is, one having no probable relation to the health and vigor of the stock. This character was the perfection of red color, that family of pullets being chosen each year which showed the deepest red color. As measured by hatchability of the eggs, the vitality of the flock fell rapidly and in 1916 only one egg was hatched and this chick did not live to mature.

A new beginning was now made, the degree of inbreeding (brother to sisters) being as close as before, but selection was now based on strong hatchability and general vigor, color being left out of account entirely. With this method there has been no evident deterioriation in the stock from 1917 to 1921, though much variability in color is naturally resulting. Such experiments, however, together with present-day genetic understanding, indicate that the success or failure of inbreeding lies in the individuals selected.

THE GERM CELLS

Studies of Sex Control. Thus far, work with rabbits to determine, if possible, some method of sex control has produced onlf negative results. Extensive measurements seemed to show that there was not such a noticeable difference in size of spermatozoa in rabbits as has been described, for example, in cattle and swine, and therefore it is possible that with other animals some method may yet be devised.

Modifying the Germ Cells. Different experiments have been made to determine how the germ plasm of animals may be modified. Deficiencies have been reported resulting from alcoholism, lead, and recently from the use of anti-lens sera.

The effect of radium on the germ glands is being studied, and interesting results have been obtained with a regard to production of sterility, but thus far no modifications of offspring have been observed which could be attributed to the radium treatment.

Inheritance in Pigeons. A rather unique series of relationships has been brought out by Miss S. V. Jones in the report on the inheritance of checks, bars, and other modifications of black in pigeons. The various stages of "bluing," the replacing of black by blue in the plumage, appear to depend on separate,

FIG. 35.—CHICK LIVES ON WHOLE MILK

This fowl, hatched June 1, received no other food than milk until October 11 when the photograph was taken.

definite, independently heritable factors, whose expression is such that each one higher in the series (producing more black) covers the effect of all those below.

"WHITE RATION" HELPED BY DRIED PORK LIVER

White corn, which is destitute of the fat-soluble vitamine, must be supplemented by some such addition as dried pork liver, wherein the vitamine occurs in abundance if the ration is to be complete. The influence of this addition has been studied on the egg production of five lots, ten each, of June hatched pullets by Mr. Halpin and H. Steenbock (Agricultural Chemistry). Although the first month with white corn and casein alone showed an egg production of 108, the white corn, casein, and pork liver showed a production of 117, dropping in June for the former to 19 eggs and in the latter to 107, with a loss of chickens in the first lot of 80 per cent and in the second lot of 10 per cent.

White corn and clear skimmilk powder gave results almost identical with those obtained when feeding white corn and casein, although an increase in egg production was noticed the second month and the number of eggs laid in June was only three, while 80 per cent of the fowls died. White corn, skimmilk powder, and pork liver, however, started the second flock at 54 eggs in January and increased the same as white corn, casein, and pork liver with a loss of only 10 per cent of the fowls. Cod liver oil is known to be very rich in fat-soluble vitamine and to have a stimulating effect under varying circumstances as a feed. This was shown in the ration of white corn, casein, and codliver oil; the flock began with 63 eggs in January, increased production in April to 83 and decreased again in June to 35, with a loss in the pen of 20 per cent due to death.

Lime Supply Influences Egg Production. Coarse oyster shell again proved the most satisfactory, fine oyster shell next, and dry bone third in experiments conducted by J. G. Halpin and E. B. Hart. While it is still impossible to explain why oyster shell gives better results than any other single source of lime material, it was shown that the addition of green stuff to the ration gives a much better result.

Use Milk for Starting Baby Chicks

A number of people have reported excellent results when the chicks are given whole milk to drink during their first days in the brooder, the whole milk being supplemented by other feed as shown in recent reports. However, when the chicks are a week or ten days old, they are gradually changed to skimmilk, but whole milk seems to be a very practical supplement to the chick's diet during the most critical time of its life—the first few days. Work has been continued along this line by Mr. Halpin and E. B. Hart (Agricultural Chemistry). A chick was never given anything but whole milk to drink from about June 1 to October 11. Although whole milk does not give normal growth due to the lack of other needed substances, this is conclusive evidence, however, of the importance of using milk in starting baby chicks.

Do Swine Need Roughage?

It is well known that not infrequently, especially in the winter, growing pigs get stiff and crippled and brood sows break down after farrowing, when giving a large flow of milk. These conditions bear some similarity to rickets, a disease of the bones which affects humans. E. B. Hart and H. Steenbock (Agricultural Chemistry) have been endeavoring to ascertain the cause of such conditions.

Among other factors studied they have carried on experiments to find whether the lack of roughage or bulky feed causes the troubles. Rations were made from corn and oil meal, to which was added 1 per cent of common salt and 2 per cent of floats (ground rock phosphate) in order to furnish the needed mineral constituents. One group was left as a check receiving only this ration, while another group received 10 per cent of finely ground paper, another group 10 per cent of charcoal, and another group 10 per cent of ordinary dirt. These animals have now been under observation for a year.

Those on the first ration without any roughage developed trouble at the end of 6 to 8 months, manifested by stiffness in the joints and such difficulty in getting on their feet that they crawled about on their knees. However, the lot receiving paper also developed this condition, indicating, apparently,

that the roughage factor was not the cause. On the other hand, those receiving charcoal did not show this condition of swollen joints and stiffness, and those receiving dirt manifested this condition to only a slight extent.

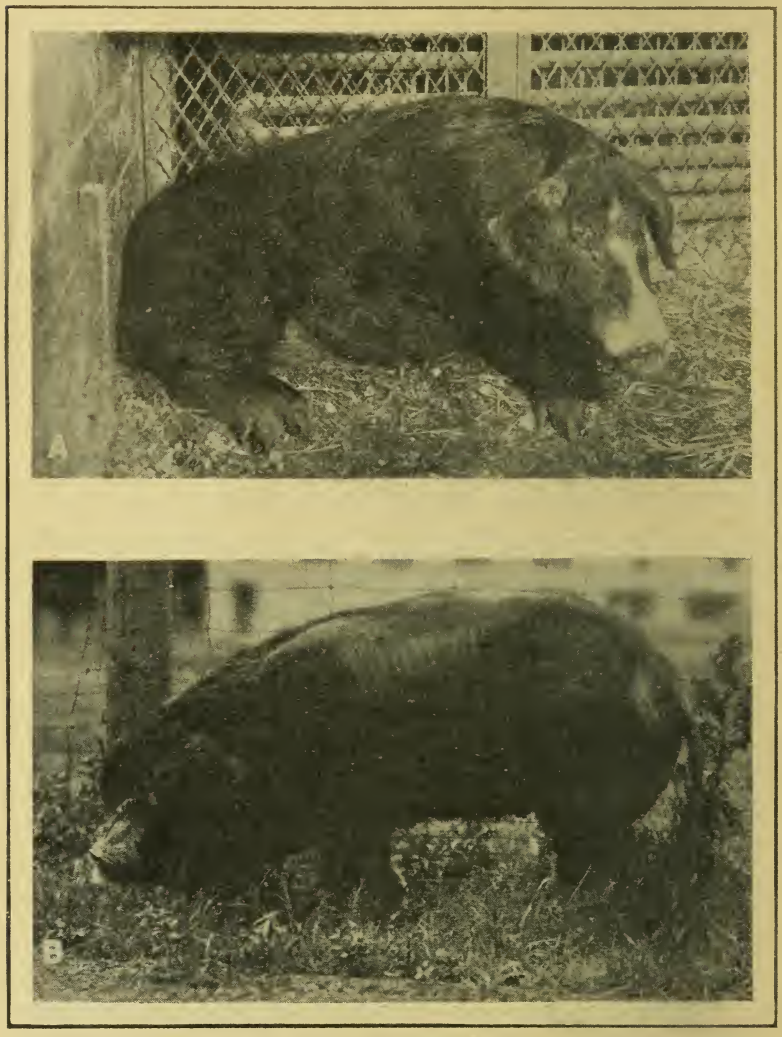


FIG. 36.—POOR FEED CAUSES BREAKDOWN

A. This sow broke down at farrowing time on a ration of yellow corn, floats, and common salt.

B. Same animal continued on the ration used previously with 20 c. c. cod-liver oil. Locomotion completely regained

As these results began to suggest a rachitic condition as the cause of the stiffness, the animals were given a daily dose of cod liver oil. The recovery was rapid and marked. One animal that was becoming very stiff and losing weight at a weight of 250 pounds, immediately began to grow at a normal rate and finally the stiffness and swollen joints disappeared.

One lot of pigs was fed only skimmilk for over a year, with no roughage whatsoever. Though they did not grow at a normal rate, no doubt due to the low supply of fat-soluble vitamine in skimmilk, no stiffness developed. This indicates that roughage itself may not be necessary for health of swine, if the ration contains all the necessary nutrients and vitamines.

Stability of the Anti-scorbutic Vitamine

The anti-scorbutic vitamine is much less stable than the fat soluble vitamine. In the spray process of manufacturing powdered milk more of the anti-scorbutic vitamine is destroyed than in the Just process (roller process). The results should not condemn milk powders made by the spray process, but they show their limitations when used as a sole source of the milk supply in infant feeding.

How the anti-scorbutic vitamine is destroyed remains obscure. It is absent in silage, but whether it is destroyed by the long continued heat or by the fermentations is still unknown. Roots and other vegetables stored during the winter appear to be less potent in their anti-scorbutic activity in the spring than when they were fresh in the fall. Continued experiments by Samuel Lepovsky (Agricultural Chemistry) have shown that certain types of fermentation appear to destroy this vitamine while other types do not. Auto-oxidation is perhaps a very active cause. Mr. Lepovsky has also continued his work on the solubility of this vitamine in order to know more of its nature. He has learned that it is soluble in alcohol and water.

The possible relation of this vitamine to maintenance of the best condition in farm animals has lead to the study of its distribution in farm feeds. While it is recognized that it is low or absent in dried materials yet there has been little knowledge of the amount in the various roots and in green material.

It has been found that 1 gram a day of green forage from oats, alfalfa, corn, or timothy will provide enough of this vitamine to protect a guinea pig from scurvy, while it takes one and a half grams of cabbage or three grams of rutabaga or turnip. Potatoes are much lower in the vitamine, 5 to 10 grams being needed. Ten grams of yellow carrots are required and 20 to 30 grams of sugar beets, sugar mangels, or table beets.

IMPORTANCE OF PLENTY OF LIME FOR STOCK

The disastrous effects of a lack of lime in the rations for breeding cows, which have been discovered in the long continued experiments by Messrs. Hart and Steenbock, have been previously reported. In these trials when cows have been fed wheat or oat straw which are low in lime, as the only roughages throughout pregnancy they have aborted or have produced dead or weak offspring. When such roughage as legume hay, which is high in lime, has been fed, the calves were normal. During the past year, cows have been fed roughages low in lime during various periods of pregnancy,

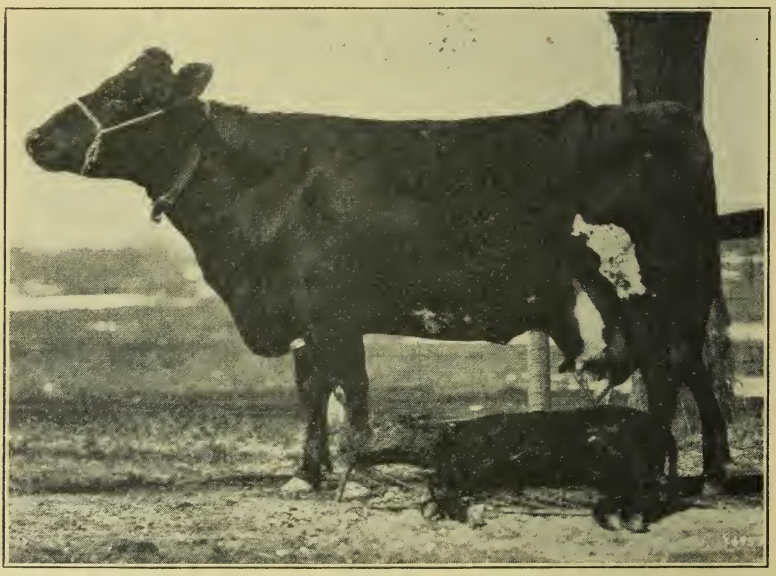


FIG. 37.—CALCIUM-RICH ROUGHAGE NEEDED

This cow received a high calcium roughage (clover hay) for the first five months of gestation and a low calcium roughage (oat straw), for the last four months of gestation. The result was a dead calf.

to find how long such rations could be fed without injurious effects. From the limited number of trials which have thus far been carried on it appears that a forage low in lime, such as straw, could be safely used as the only roughage for a part of the gestation period, but not during the last three to four months when the most growth occurs in the fetus.

The experiments previously mentioned are being continued to find whether hay grown on very acid soil produces poor results with breeding stock, due to a low lime content. Analyses of timothy hay and corn stover grown on various soils show that the lime content of the forage varies widely depending on the amount of lime in the soil. For instance timothy hay from an acid marsh contained only 0.41 per cent calcium oxide (lime) and corn stover from acid soils only 0.33 to 0.49 per cent calcium oxide. Such hay or stover, supplied as the only roughage, along with farm grain, would make a ration so low in lime that in all probability it would produce bad results if fed to cows through pregnancy. On account of some popular prejudice against barley, in these trials there has also been studied the effect of using barley as the only grain for breeding cattle. However, entirely satisfactory results were secured when barley was fed as the only grain with corn stover fairly high in lime.

Yellow Versus White Corn for Stock Feeding

Experiments have been continued by Messrs. Morrison, Fargo, and Bohstedt to determine the relation to swine feeding of the fact that yellow corn is rich in fat-soluble vitamine, while white corn contains but little. Four separate trials have now been concluded in this investigation. These trials show clearly that yellow corn produces decidedly larger and more economical gains than white corn when fed to pigs not on pasture, with such supplements as skimmilk, whey, or linseed meal, none of which are high in the fat-soluble vitamine. For pigs on excellent pasture there has been no difference between the value of yellow and white corn, due to the fact that green plants are rich in the fat-soluble vitamine. However, in the fall, when the pasture became scant, the pigs on white corn soon began to fall behind those receiving the

yellow corn. Later when the two lots were taken off pasture, those fed yellow corn far out-stripped the less fortunate lot. Even when fed with tankage or meat meal, which may contain some fat-soluble vitamine, yellow corn has usually been decidedly better than the white corn.

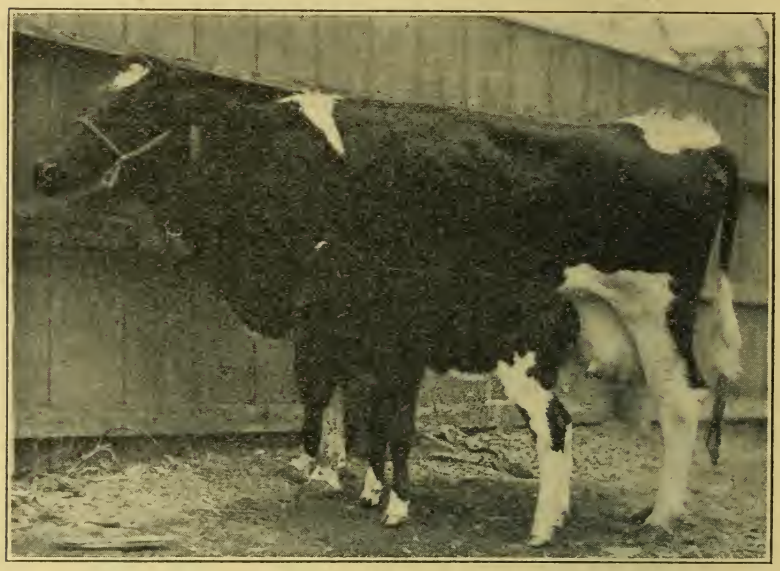


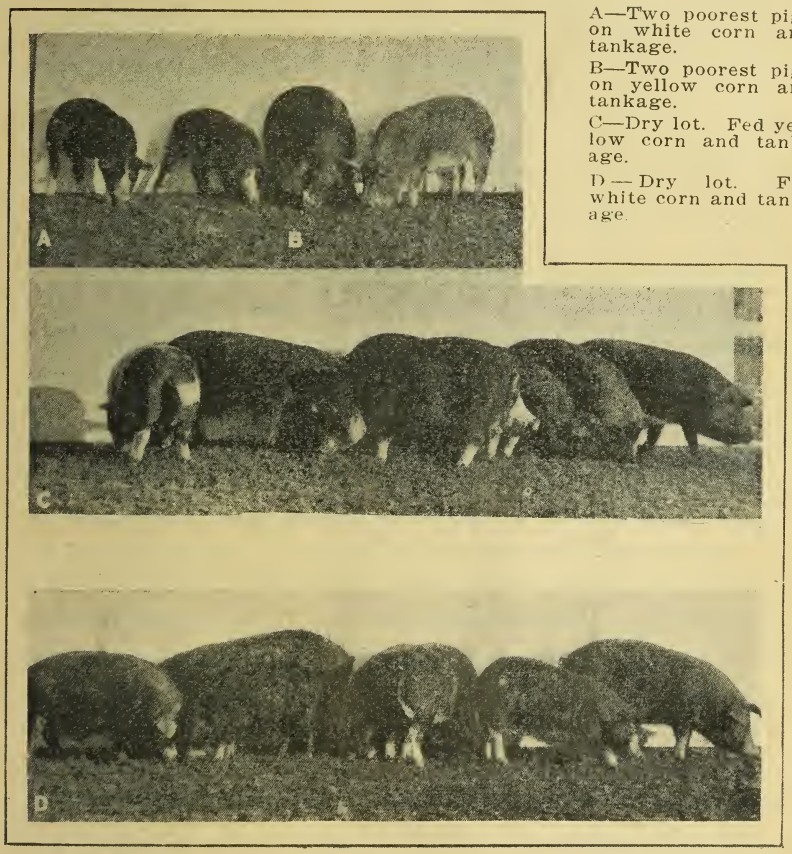
FIG. 38.—RESULT OF FEEDING CALCIUM-RICH ROUGHAGE

This cow received a calcium-rich ration (clover hay) for 7 months of the gestation period and a calcium-low roughage (oat straw) for the last two months of gestation. The result was a successful reproduction. (Compare with figure 37.)

In a trial which has just been concluded, very striking results have been secured in the comparison of white and yellow corn when fed with various common protein-rich supplements. In this experiment, which began July 20, uniform lots each of 8 pigs, averaging 60 pounds in weight at the start, were fed for 126 days. One lot was self-fed a mixture of yellow corn and tankage, while another lot was self-fed a mixture of white corn with the same proportion of tankage. The pigs on the yellow corn and tankage made satisfactory gains, averaging 1.06 pounds per head daily. They were purchased feeder pigs and were not of the best breeding or conformation or their gains would have been larger. The pigs fed white corn and tankage gained only 0.63 pound per head daily.

While the pigs fed yellow corn and tankage required but 447 of corn and tankage for each 100 pounds gain, those fed the white corn and tankage required 554 pounds of feed.

Even more striking results were secured where yellow corn was compared with white corn, with skimmilk as the supplement. The pigs fed yellow corn and skimmilk were thrifty and made the satisfactory gain of 1.0 pound per head daily, requiring 422 pounds of corn and 628 pounds of skimmilk for



A—Two poorest pigs on white corn and tankage.

B—Two poorest pigs on yellow corn and tankage.

C—Dry lot. Fed yellow corn and tankage.

D—Dry lot. Fed white corn and tankage.

FIG. 39.—YELLOW CORN BETTER PORK-MAKER THAN WHITE CORN

each 100 pounds gain. At first the pigs on white corn and skimmilk did practically as good as those fed the yellow corn and skimmilk, but finally the lack of the fat-soluble vitamine in their ration produced serious results, and finally all but three of the pigs died. The common cause of death seemed

to be pneumonia, which agrees with the results secured by Mr. Steenbock in his experiments with rats in which he has found that a deficiency of the fat-soluble vitamine often produces death from respiratory troubles, especially pneumonia.

Even the pigs which were so vigorous that they were able to live on the white corn and skimmilk ration throughout the experiment made unsatisfactory gains and required considerably more feed for 100 pounds gain than the entire lot fed yellow corn and skimmilk.

Another lot of pigs was fed yellow corn and linseed meal along with skimmed whey, while a sixth lot was fed white corn with linseed meal and whey. In this comparison the yellow corn again proved decidedly superior, but none of the pigs fed the white corn, linseed meal, and whey died during the experiment, doubtless due to the fact that linseed meal, though not rich in the fat-soluble vitamines, contains more of it than does white corn.

The lesson of these trials is obvious. If yellow corn is available, do not use white corn for feeding pigs in the winter in dry lot. Save the white corn for feeding in summer on pasture or use it for feeding other stock. If white corn must be fed to pigs in winter, see that they get some choice bright green alfalfa hay or hay from other legumes. Young pigs cannot make good use of much hay, even if it is of the best quality, so they may not make quite as good gains as if they had been fed yellow corn, even though they are supplied with legume hay. Yellow stock carrots, which are rich in the fat-soluble vitamine, have been found to be excellent to feed with white corn to pigs, but carrots are rather an expensive feed in most parts of the country.

Yellow Versus White Corn for Other Stock. So far as is now known, white corn is as good as yellow for horses, dairy cattle, beef cattle, and sheep, if they are fed ordinary well balanced rations, including plenty of good, green-colored hay. In an experiment carried on this summer by Messrs. Morrison, Hulce, and Humphrey it was found that even for calves fed whey, which is low in the fat-soluble vitamine, white corn appeared to give as good results as yellow corn, probably due to the fact that calves begin to eat hay when only two to three

weeks old, and good quality legume hay was supplied in this trial. Whether there is any difference in the feeding value of silage from yellow and white corn is a matter for future experiments to decide. At least excellent results are secured from silage made from white corn when fed to cattle and sheep. Preliminary experiments by the Poultry Husbandry Department indicate that yellow corn is apparently superior to white for chickens which do not receive in summer plenty of fresh, green feed, or in winter an abundance of clover or alfalfa chaff, sprouted oats, or similar green stuff.

Home-Grown Rations for Milk Production

Purchased protein-rich concentrates are commonly high in price compared with farm grains; consequently there is much interest among dairymen on the question as to whether they can provide for their herds satisfactory home-grown rations, thus avoiding the necessity of buying expensive concentrates. In metabolism trials previously reported which have been carried on by the Agricultural Chemistry and Animal Husbandry departments, it was found that cows would keep up quite a large flow of milk without losing nitrogen from their bodies if fed an abundance of alfalfa hay, corn silage, and corn. Similar results were secured when barley or oats were fed as the grain, the amount of each grain being adjusted so as to provide equal amounts of protein, and starch being added to the barley and oats rations to compensate for the fact that these grains are lower in net energy than corn. When clover hay, which is much lower than alfalfa in protein, was fed in place of alfalfa hay, high producing cows lost nitrogen steadily.

During the past year similar metabolism trials were carried on with alfalfa hay, but the rations were limited merely to the hay, corn silage, and corn grain, barley, or oats, without the addition of any starch. When barley or oats replaced corn, amounts supplying equal quantities of protein were fed. With corn or barley as the grain a normal flow of milk was maintained and the cows did not lose nitrogen from their bodies. However, with oats as the grain, the cows lost nitrogen, not due to a lack of protein in the feed, but due to the fact that oats are much lower in net energy than corn or barley.

A trial was also carried on by Messrs. Morrison, Hulce, and Humphrey to study the effect in practical herd feeding of a home-grown ration in which the protein was chiefly supplied by alfalfa hay. One lot of 5 cows was fed for 147 days on a ration of 10.0 pounds alfalfa hay, 32.6 pounds corn silage, and 7.2 pounds of a mixture of half ground corn and half ground oats. This home-grown ration had a nutritive ratio of 1:7.1, thus providing as much protein as recommended in the Haecker feeding standards.

A similar lot of cows was fed the same ration except three-fourths pound each of linseed meal and cottonseed meal were substituted for an equal weight of corn and oats, thus providing more protein. This ration had a nutritive ratio of 1:5.9.

In this trial the ration including the linseed and cottonseed meal did not prove superior to the excellent home-grown ration. In fact, probably because of the remarkably persistent high production of one cow, more milk and butter fat was produced on the latter ration. However, the cows on this ration did not make quite as much gain in live weight during the trial as on the ration richer in protein. Later, trouble has been experienced in getting in calf the cow previously mentioned, which gave an unusually high production on the home-grown ration. Whether or not this is due to the fact that her ration was not very high in protein, is still a question. Trials are being continued to study further the efficiency of such home-grown rations. The data thus far secured show that cows of fairly high production will maintain normal production for the winter period on a home-grown ration, including an abundance of alfalfa hay. However, for year round feeding of very high-producing cows it would appear wise to feed a somewhat higher allowance of protein than such a ration will furnish.

STUDIES OF VITAMINES

In determining the exact importance of the different vitamines in human nutrition and in stock feeding it is essential that the approximate amount of each vitamine in different common food stuffs be determined. Mr. Steenbock, Miss Mariana Sell, and Elmer Nelson (Agricultural Chemistry) have therefore carried on trials with small laboratory animals

(rats) to study the distribution of the vitamines, especially the fat-soluble vitamine, in milk and milk products, and also in various plant materials.

Fat-soluble Vitamine in Milk. Whole milk has been found to be very rich in its content of fat-soluble vitamine compared with the amount of water-soluble vitamine it contains. Two cubic centimeters a day of whole milk was sufficient to produce normal growth in rats fed white corn, which contains practically none of this vitamine. In comparison with this it takes 16 cubic centimeters of milk a day to provide enough water-soluble vitamine for a rat to grow normally.

While whole milk is rich in the fat-soluble vitamine, the amount of this vitamine in centrifugal skimmilk is only one-tenth or less than in whole milk. This fact is of much importance in swine and poultry feeding. Furthermore it has a profound bearing on human nutrition, especially in the use of "filled milk," which is evaporated skimmilk to which cocoanut oil has been added, as a substitute for whole milk. "Filled milk" has been found to be so deficient in fat-soluble vitamine that it will not sustain normal growth in rats, even when liberal amounts are supplied.

It has been reported that in previous trials the content of anti-scorbutic vitamine in milk was found to be much lower ordinarily in winter than in summer when the cows were on pasture. Though cows fed good hay in winter secure amounts of fat-soluble vitamine in these feeds, it was found that on ordinary rations milk was considerably lower in this vitamine than under pasture conditions.

Fat-Soluble Vitamine

Stability of the Fat-Soluble Vitamine. The fat-soluble vitamine is not of an extremely unstable nature, for it can be boiled with acids and alkalies of a few per cent concentration. It can be treated with hydrogen or oxygen in acid or alkaline solution with little or no destruction, yet the data seem to indicate that under certain conditions oxygen destroys it quite readily, as is apparently the case in milk powders made by the spray process. Furthermore, it is destroyed to some extent by direct rays of the sun. This would indicate that hay

exposed too long in the swath to the direct sunlight would be lower in its content of the vitamine than hay cured in the windrow or cocks.

Yellow Coloring Related to Fat-Soluble Vitamine. The discovery that the fat-soluble vitamine occurred in yellow corn while it did not occur in white corn has now led to further experiments. In the yellow corn kernel itself, this vitamine has been found especially abundant in the endosperm where the bulk of the pigment is present. The germ contains little of it, in correspondence with the low pigment content, and out of harmony with its high content of fat, with which this vitamine is so often associated. It has been previously found that light colored butter fat tends to be lower in fat-soluble vitamine content than deeper colored butter fat. In like manner it has been found that light colored beef fats are usually poorer in the vitamine than the higher colored beef fats. A similar situation has been found in the case of egg yolks produced under ordinary feeding conditions. Those richest in yellow color are richest in the fat-soluble vitamine. However, it is possible to produce a light colored yolk very rich in the fat-soluble vitamine by the use of pork liver or cod liver oil, both of which are poor in the yellow pigment but rich in the vitamine.

HYDROLYZED SAWDUST FOR DAIRY COWS

It was reported last year that in a feeding trial by Messrs. Morrison, Humphrey, and Hulce, hydrolyzed sawdust prepared by treating sawdust with a diluted acid under pressure, was successfully used as part of the concentrate mixture for dairy cows. In this trial two pounds of sawdust approximately replaced one pound of barley. While at the present prices of farm grains throughout the corn belt there is no probability that hydrolyzed sawdust will be of any importance as a live-stock feed, this past year another trial was conducted to obtain further information concerning the value of hydrolyzed sawdust. Inasmuch as in certain districts of the country, especially in the far West, carbohydrate-rich feeds are commonly high in price the conversion of sawdust into a stock food may perhaps be of economic importance.

In this trial two lots each of three cows were fed for seventy days. One lot received an excellent ration consisting of alfalfa hay, corn silage, and a concentrate mixture made up of 60 parts yellow corn, 20 parts wheat bran, and 20 parts linseed meal. The ration for the other lot was the same except that hydrolyzed sawdust made from western white pine was gradually substituted for ground corn at the rate of two pounds of the sawdust for one pound of corn. When the percentage of sawdust in the concentrate mixture had reached 40 per cent, two cows failed to eat the mixture well and the proportion of hydrolyzed sawdust was reduced to one-third and no difficulty was experienced throughout the trial in getting the cows to eat this mixture. In the previous trial the cows were fed by the reversal method, remaining on the hydrolyzed sawdust for only a brief time; but in this trial, however, they were maintained on the sawdust throughout the entire period. The cows remained in good condition throughout, the only effect of the hydrolyzed sawdust apparently being a slight constipating tendency. And while the milk and fat production on the two rations was practically the same, the cows maintained their live weight slightly better on the ration containing the hydrolyzed sawdust. The data, therefore, substantiate those secured in the previous trial, indicating that hydrolyzed sawdust may be substituted for corn or barley in the concentrate mixture for high-producing dairy cows without affecting the normal milk flow, and that the hydrolyzed sawdust may form one-fourth to one-third of the concentrate mixture.

As these trials have shown that hydrolyzed sawdust may be used successfully under proper conditions for feeding dairy cattle when economic conditions warrant it, the trials will not be continued further at the present time, but it is of interest to note that the United States Department of Agriculture has taken up experimental work on this subject and also one of the eastern experiment stations is beginning a study of the question.

Economical Rations for Dairy Calves

Where there is an abundance of skimmilk for calf feeding, the raising of vigorous dairy calves is relatively simple, but on an increasing number of Wisconsin farms there is none

now available. Over large sections the milk is sold to condenseries or shipped to city markets. In cheese producing districts plenty of whey is available for calf feeding, but such poor results have commonly been secured with this dairy by-product that many farmers make no attempt to use it for this purpose.

To study the most economical methods of raising dairy calves on farms where plenty of skimmilk is not available, calf feeding trials have been carried on the past year by Messrs. Morrison, Hulce, and Humphrey. As a check lot, one lot of calves was fed a liberal allowance of skimmilk (14 pounds a head daily) with a suitable concentrate mixture and legume hay. This lot made the excellent average daily gain of 1.68 pounds for 24 weeks. Another lot, fed only 10 pounds of skimmilk a day, with slightly more concentrates, gained 1.49 pounds per head daily, a satisfactory gain, though slightly below the first lot.

A third lot was fed no skimmilk, but was raised on a minimum amount of whole milk, which amounted to only 350 to 400 pounds for each calf. This was supplemented by a simple concentrate mixture, rich in protein, consisting of equal parts oats, corn, linseed meal and wheat bran. After the first two months, the calves were fed only this mixture with hay and water, no expensive calf meal being fed. This lot also made the satisfactory gain of 1.44 pounds a head daily.

Surprisingly good results were secured with lots fed whey, supplemented by a concentrate rich in protein, consisting of corn 30 pounds, standard middlings 30 pounds, and linseed meal 40 pounds. The whey was skimmed whey and no attention was paid to variations in sourness after the calves were used to this feed. Lots thus fed whey gained on the average 1.48 pounds per head daily, this satisfactory gain being due in all probability to the fact that the whey was never allowed to stand in a filthy tank or can and was fed under sanitary conditions by a careful herdsman. Before definite conclusions are drawn concerning the value of these and other rations for calf raising, the studies will be carried further in future trials.

Relationship of Vitamines to Use of Lime

The theory that some vitamine controls or affects the ability of animals to assimilate and use the lime in their feed, which was advanced recently by Messrs. Hart and Steenbock (Agricultural Chemistry), has been confirmed by experiments carried on the past year. In metabolism experiments with high-producing dairy cows, they have shown a greater ability to assimilate the lime (calcium) from fresh green alfalfa than from alfalfa hay, supporting previous observations that fresh green forages apparently contain some vitamine or other substance which increases the assimilation of lime from the feed.

In metabolism trials by Messrs. Hart, Steenbock, and Hoppert milk goats have been easily brought into negative lime balance on a ration of grains and oat straw so that they were losing this mineral from their bodies. To such a ration various additions were made in an effort to determine whether lime assimilation from the feed was influenced by any of the three vitamines thus far positively identified: i. e., the fat-soluble vitamine, the water-soluble vitamine, and the anti-scorbutic vitamine. The results secured up to the present time indicate that neither the water-soluble vitamine or the anti-scorbutic vitamine affect the assimilation of lime. When cod liver oil, which is exceedingly rich in the fat-soluble vitamine, was added to the ration, even in small amounts, the animals were able to use more of the lime in the ration. However, in one trial with butter-fat, which is also rich in fat-soluble vitamine, no such response followed. Therefore, it is yet undecided whether it is the fat-soluble vitamine in cod liver oil and in fresh green forages which increases the assimilation of lime, or whether it is some entirely different vitamine or other substance.

Dogs have also been used in similar studies by Messrs. Steenbock and Elmer Nelson. A ration low in fat-soluble vitamine, which consisted of skimmed milk, rolled oats, and white corn meal mush, plus calcium, phosphate, and common salt, has produced typical rickets (bone disease) within six to seven weeks in young dogs. However, when a small allowance of cod liver oil was added to the same ration normal growth resulted. Various other additions to such a ration

are being tested in the hope that it may be possible to find definitely whether the factor governing the use of lime is the fat-soluble vitamine or not.

FIG. 40.—COD-LIVER OIL RICH IN FAT-SOLUBLE VITAMINE

Fed on a ration of oatmeal, white cornmeal, calcium phosphate, salt, and sterilized skim milk. Insufficient for proper growth.
The same dog after being cured by a daily feeding of cod-liver oil—entire constitution apparently stimulated by the potency of the vitamine.

In these experiments it has been found that on a ration low in fat-soluble vitamine dogs suffer from the same eye disease (xeropthalmia) as do rats on such a diet.

TECHNICAL ARTICLES

Much of the technical scientific output of the experiment station staff is first presented to the scientific public through the medium of the science periodicals and publications of scientific societies. The publication of such matter enables our workers to have their results scrutinized by their scientific colleagues. The following articles have been published during the past year, ending June 30, 1921:

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Arzberger, C. F., Peterson, W. H., and Fred, E. B. Certain factors that influence acetone production by bacillus acetoethylicum. Jour. Biol. Chem. 44:2. 1920.

Bauer, F. C. The relation of organic matter and the feeding power of plants to the utilization of rock phosphate. Soil Science. 12:21-41. 1921.

Beach, B. A. Contagious abortion of sows. Proc. Wis. Vet. Med. Assn. 6:87-89. 1921.

Davis, Marguerite and Outhouse, Julia. Effect of a ration low in fat-soluble "A" on the tissues of rats. Am. Jour. Diseases of Children. 12:307-311. 1921.

Dickson, J. G. The relation of certain nutritive elements to the composition of the oat plant. Am. Jour. Bot. 8:256-274. 1921.

Dickson, J. G. The influence of soil temperature on the development of the seedling blight of cereals caused by Gibberella saubinetii. Phytopath. 11:35. 1921.

Dickson, J. G., Johann, Helen, and Wineland Grace. Second progress report on the Fusarium blight (scab) of wheat. Phytopath. 11:35. 1921.

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Fluke, C. L. The pea moth in Wisconsin. Jour. Economic Entomology. 14:94-98. 1921.

Fred, E. B. The fixation of atmospheric nitrogen by inoculated soy beans. Soil Science. 11: No. 6. 1921.

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Fred E. B., Wright, W. H., and Frazier, W. C. Field Tests on the inoculation of canning peas. Soil Science. 11: No. 6. 1921.

Frost W. D. Improved technic of the micro or little plate method of counting bacteria in milk. Jour. Infectious Diseases. 28:176-184. 1921.

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Hadley F. B. Detecting sick cows by the milk. The Vet. Alumni Quar. 8:97-103. 1921.

Hadley, F. B. Products derived from the animal body. Vet. Med. 16:30 et seq. 1921.

Hadley, F. B., and Beach, B. A. Two unusual case reports. Jour. Am. Vet. Med. Assn. 59:362-365. 1921.

Haner, Reba Cordelia, and Frost, W. D. The characteristics of the microcolonies of some pathogenic cocci. Jour. Infectious Diseases. 28:270-274. 1921.

Hart, E. B., Halpin, J. G., and Steenbock, H. Use of synthetic diets in the growth of baby chicks—a study of leg weakness in chickens. Jour. Biol. Chem. 43: No. 2. 1920.

Hart, E. B., and Humphrey, G. C., wth cooperation of Lepkovsky, S. Can "home grown rations" supply proteins of adequate quality and quantity for high milk production? II. Jour. Biol. Chem. 44: No. 1. 1920.

Hart, E. B., Steenbock, H., and Ellis, N. R. Influence of diet on the antiscorbutic potency of milk. Jour. Biol. Chem. 42: No. 3. 1920.

Hart, E. B., Steenbock, H., and Ellis, N. R Antiscorbutic potency of milk powders. Jour. Biol. Chem. 46: No. 2. 1921.

Hastings, E. G., and Davenport, Audrey. The relative value of the methylene blue reduction test, the bromthymol blue test, and the bromcresol purple test in determining the keeping quality of milk. Reprinted from Jour. Dairy Science. 3: No. 5. 120.

Hastings, E. G., and Davenport, Audrey. The effect of pasteurization on the number of bacteria in milk when this is determined by the direct microscopic count. Reprinted from Jour. Dairy Science. 3: No. 6. 1920.

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Hibbard, B. H. Fair prices. Nat. Stockman & Farmer. Dec. 25, 1920.

Hibbard, B. H. What the farmer may expect from the tariff. Nat. Stockman & Farmer. April 14, 1921.

Hibbard, B. H. Stabilization of prices. Am. Econ. Rev. June, 1921.

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Jones, L. R., and Walker, J. C. The relation of soil temperature and other factors to onion smut and infection. Phytopath. 11:52. 1921.

Jones, L. R., and Williamson, M. M. Bacterial leaf spot of red clover. Phytopath. 11:50. 1921.

Jones, Sarah V. H. Inheritance of silkiness in fowls. Jour. Heredity. 12:117-128. 1921.

Johnson, A. G., and Leukel, R. W. The nematode disease of cereals. Phytopath. 11:41. 1921.

Johnson, James. Fusarium wilt of tobacco. Jour. Agr. Research. 20: 515-535. 1921.

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Morrison, F. B., and Humphrey, G. C., and Hulce, R. S. Corn stover silage versus corn silage for milk production. Record of Proceedings of Annual Meeting of the Am. Society of Animal Production. 58-61. 1920.

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Parker, F. W. Methods of studying the concentration and composition of the soil solution. Soil Science. 12:209-232. 1921.

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Parsons H. T., and others. Experimental rickets; effect of cod-liver oil administered to rats with experimental rickets. Jour. Biol. Chem. 45:343. 1921.

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Peterson, W. H., and Fred, E. B. The production of acetaldehyde by certain pentose-fermenting bacteria. Jour. Biol. Chem. 44: No. 1. 1920.

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Swenehart, John. Utilization of war-salvaged picric acid for land clearing and other agricultural work. Special Bulletin. Agricultural Experiment Station. 1921.

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Walker, J. C. A macrosporium rot of onion. Phytopath. 11:53. 1921.

Walker, J. C. Experiments upon formaldehyde drip control of onion smut. Phytopath. 10:323-327. 1920.

Walker, J. C. The occurrence of dodder on onions. Phytopath. 11:53. 1921.

Walker, J. C. Onion smudge. Jour. Agr. Res. 20:685-721. 1921.

Walker, J. C. Rust on onion followed by a secondary parasite. Phytopath. 11:87-90. 1921.

PUBLICATIONS

A total of seventeen new popular bulletins and four reprints were published this past year by the Experiment Station, an increase of 30 per cent over last year. Two new research bulletins were also issued. Eight new circulars and six reprints constitute the publications of the Extension Service.

A very brief digest of each bulletin is given below:

POPULAR BULLETINS

Bulletin 317.—Off-Year Apple Bearing. (R. H. Roberts). Biennial bearing is not a fixed habit of trees; it may be modified with proper growth conditions.

Bulletin 318.—Credit Needs of Settlers in Upper Wisconsin. (R. T. Ely, B. H. Hibbard, and A. B. Cox). A thorough discussion of financial needs on cut-over farms during the pioneering stage and farm improvement stage.

Bulletin 319.—Experiments in Farming. Annual Report of the Director of the Experiment Station for 1918-1919. (H. L. Russell and F. B. Morrison.) The results secured in experimental work during the year.

Bulletin 320.—Clear More Land. (John Swenehart.) A handbook on land clearing for the farmer on cut-over land.

Bulletin 321.—Cheesemakers Save by Figuring Costs. (J. L. Sammis and O. A. Juve.) A summary of all costs of making cheese is required to determine a price which will yield a fair labor income.

Bulletin 322.—Marketing by Federations. (Theodore Macklin.) An explanation of the working of the Wisconsin Cheese Producers Federation as an example to be followed in forming marketing federations.

Bulletin 323.—New Farm Facts. Annual Report of the Director 1919-1920. (H. L. Russell and F. B. Morrison.) Wisconsin is prospering through the application of science to the everyday efforts of country life.

Bulletin 324.—What the Retailer Does With the Consumer's Dollar. (Theodore Macklin and P. E. McNall.) A detailed discussion of the division of a consumer's dollar, presenting the results of an investigation among Madison retailers.

Bulletin 325.—Dairy Barns. (O. R. Zeasman, G. C. Humphrey, and L. M. Schindler.) Important points to consider in building a convenient, economical, and durable dairy barn.

Bulletin 326.—Wisconsin Rye. (R. A. Moore and B. D. Leith.) With its many excellent qualities, rye is the most adaptable of small grain crops.

Bulletin 327.—Cost of Canning Wisconsin Peas. (Theodore Macklin.) A discussion of the factors involved in figuring the costs on one of Wisconsin's important industries.

Bulletin 328.—The Farm Well Planned. (D. H. Otis.) Among the many points suggested for a well planned farm are large, regular fields, and a good rotation schedule.

Bulletin 329.—Field Peas for Wisconsin. (E. J. Delwiche.) It is highly important that Wisconsin farmers become better acquainted with proper methods of raising one of their profitable crops—field peas.

Bulletin 330.—Profitable Root Crops. (E. J. Delwiche.) Roots are a splendid supplement to silage and grain feed, and are of especial value where no silo exists.

Bulletin 331.—Potato Scab. (J. W. Brann and R. E. Vaughan.) Corrosive sublimate has proved the best disinfectant for seed potatoes, as it kills the scab organisms on the surface of the tubers, thus preventing infection of the soil.

Bulletin 332.—Farms Follow Stumps. (H. L. Russell.) The results secured on the branch stations with live stock, seeds, and soil, converting the cut-over lands into well developed farms.

Bulletin 333.—How to control American Foulbrood. (H. F. Wilson.) As American Foulbrood is a bacterial disease carried in the honey and old combs, by getting rid of the infected honey and combs the disease may be controlled.

RESEARCH BULLETINS.

Research Bulletin 48.—Fusarium Resistant Cabbage. (L. R. Jones, J. C. Walker, and W. B. Tisdale.) A discussion of results secured in experiments with cabbage, resistant to cabbage yellows.

Research Bulletin 49.—Influence of Rations Restricted to the Oat Plant on Reproduction in Cattle. (E. B. Hart, H. Steenbock, and G. C. Humphrey.) Proper mineral content is an important consideration in the balancing of a good feed ration.

THE WISCONSIN AGRICULTURAL EXPERIMENT STATION, IN ACCOUNT WITH THE UNITED STATES APPROPRIATION.

1920-1921	Dr.	Cr.
To receipt from treasurer of the United States, as per appropriation for the year ending June 30, 1921, under the acts of Congress approved March 2, 1887, and March 16, 1906	$30,000.00	
By salaries		$17,200.00
By labor		5,686.25
By publications		458.36
By postage and stationery		22.64
By freight and express		145.52
By chemicals and laboratory supplies		928.98
By seeds, plants and sundry supplies		1,029.33
By fertilizers		119.28
By feeding stuffs		2,415.91
By tools, machinery and appliances		396.78
By furniture and fixtures		100.28
By scientific apparatus and specimens		1,142.66
By live stock		312.00
By traveling expenses		41.01
By contingent expenses		1.00
Total	$30,000.00	$30,000.00

AGRICULTURAL EXPERIMENT STATION
THE UNIVERSITY OF WISCONSIN
STATIONS
MAIN
BRANCH
DEMONSTRATION
COUNTY REPRESENTATIVE

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March, 1922

Wisconsin Oats

AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF WISCONSIN
MADISON

DIGEST

Oats is a leading Wisconsin crop. The corn acreage is only about four-fifths that of oats; barley is about one-fourth and rye and wheat are each about one-fifth of the oat acreage. Page 3.

Oats yields about the same number of pounds to an acre as barley, but a pound of oats has less feeding value. Page 3.

Northern United States, Canada and the north European countries yield the heaviest oats and the largest crops. The late and medium late large kerneled varieties are particularly well adapted to these regions. Page 4.

Lodging is the most difficult problem in oat production. The most common cause is a very rich soil. The best control measures are rotations and cultural practices which will reduce the fertility for the oat crop. Page 5.

A heavy hull reduces the feeding value of oats. Varieties differ in the amount of hull; the difference in seasons will also cause a variation in the percentage of hull. As low as 24 per cent and as high as 52 per cent of hull have been found in oats. Page 6.

Five pedigree varieties of outstanding merit have been produced by the Wisconsin Experiment Station. Each of these has been developed to meet particular conditions. Pages 7-10.

Oats should not be sown on rich ground. In the rotation it should follow corn or another small grain. Page 11.

The broadcaster will give as high yields as the drill on heavy clay soils. On light soils, the drill gives best results. In such soils the main object is to get the grain down deep enough to get plenty of moisture. Pages 12-13.

Early oats make better nurse crops as a rule than do late oats. Page 14.

Wisconsin Oats

B. D. Leith and E. J. Delwiche

Oats is the most important grain crop Wisconsin produces. This grain is grown upon the great majority of farms in the state. Compared with other leading cereal crops for the past five years (1917-21), the corn acreage is about four-fifths that of oats, barley about one-fourth, and rye and wheat each about one-fifth of the oat acreage.

Because oats is so common, however, it is often grown under conditions entirely unsuited to it. While it does respond to poor treatment better than any cereal crop, yet certain care in the choice of the variety and kind of soil are necessary for best results.

Oats Compared With Barley

A comparison of barley and oat yields from this state shows a much better money return from an acre of barley than of oats. This is explained because oats is often grown on poorer soils than barley.

The data from the Hill Farm at the University of Wisconsin, where oats and barley are both grown, give a much fairer comparison.[1] A four-year average of oats is 62.3 bushels per acre or 1,994 pounds; and barley for the same four years gave 40.5 bushels per acre or 1,944 pounds. This makes the comparison very close, as the price per pound of these two grains does not vary much. In feeding value there is an advantage in favor of barley for in total digestible nutrients 88⅔ pounds of barley is worth 100 pounds of oats.[2]

While barley has some advantage over oats as a feed, yet oats has a place on the farm that barley cannot always fill. It is the most palatable horse feed; it is a more agreeable crop to

[1] *Wisconsin Rye;* Wis. Agr. Exp. Sta. Bul. 326, p. 4.
[2] *Feeds and Feeding,* Henry and Morrison.

handle; it may be used for hay in combination with peas or alone; it is better adapted to new breakings than barley; and on light sandy soils oats will give good returns where barley would be a failure.

CLIMATE FOR OATS

The heaviest oats and the highest yields are produced in northern United States, Canada, and the north European countries, where hot weather at filling time rarely occurs. The late and medium late large kerneled varieties are particularly well adapted to this region. Most of the varieties of side oats are included in these groups.

South of this belt the mid-season varieties do best. Again south of this, the early small kerneled varieties are best suited because they are more drouth and heat resistant than the later varieties. Hot climates must have varieties suited to such conditions and these are not high yielders.

Northern Wisconsin is in the late oat region. Central Wisconsin produces mid-season oats best and the mid-season and early oats overlap below the central part of the state. Southern Wisconsin and Illinois grow early oats almost exclusively.

INCREASE THE YIELD

Since oats is so common, it is often grown under conditions entirely unsuited to it. In some cases it is merely scattered over the ground and worked in; again it is often sown on ground entirely too rich for it. It responds to poor methods of handling better than other cereal crops, but the best returns will be obtained if it is planted on soils suitable for it and if the seed is sown properly.

Too many growers look upon oats as a filler in a crop rotation to be used for feed only, and therefore think that any kind of oats will serve the purpose. This is a serious mistake. The great difference in the producing power of different varieties of oats, is shown in the tables of yields of the different varieties in the appendix, page 24.

Pedigree strains superior to the original mixed commercial varieties, have been developed by the agronomy department of the College of Agriculture. This pedigreed oats can be grown for seed at practically the same cost as feed oats. The oat crop can

thus be made to serve the double purpose of a cash crop and a feed.

LODGING IN OATS

The fact that oats lodges easily is one of the greatest difficulties in obtaining a profitable crop. This not only reduces the oat

FIG. 1.—THRESHING STATE'S PRIDE OATS FROM THE SHOCK.

Where the farmer owns his own threshing rig he can save by shock threshing.

yield but also smothers out the new seeding when it is sown with the oats. With the increase in dairying, therefore, there is more oat lodging, due to the greater fertility of the soil.

EFFECT OF RATE OF SEEDING UPON LODGING

The results at the Marshfield branch station indicate strongly that heavy rates of seeding will cause lodging.

TABLE I.—PERCENTAGE OF LODGING AT MARSHFIELD

Rate of seeding	Lodging percentage			
	1917 and 1918	1919	1920	1921
1 bu.	No lodging	0	0	0
2 bu.	No lodging	33%	0	30%
3 bu.	No lodging	100%	50%	0
4 bu.	No lodging			60%

The variety used in the tests was White Jewel Pedigree No. 132, a strain possessing much resistance to lodging.

LODGING AND SUPPLY OF PLANT FOOD

That lodging of oats can be only partially controlled, at best, by various fertilizer treatments, is shown by tests in progress at Marshfield and Madison. A large supply of organic matter in the soil seems to favor lodging by increasing the moisture holding capacity of the soil, thus furnishing more water than the plant needs for normal development. The plant gets an excess of nitrates under these conditions, which is another factor in causing lodging. Seasons of abundant rainfall tend to produce a rank growth of straw.

No solution for entirely preventing lodging has been found. Any variety of oats will lodge on rich ground. Some kinds lodge more readily than others; some fill out fairly well when lodged, while others produce such light kernels that they are practically valueless.

Where lodging is troublesome, reduce the fertility before sowing oats by growing one or two crops of corn or a crop of barley, spring wheat, or winter grain, before putting in to oats. Do not work up a fine seed bed. Disk the corn stubble instead of plowing it. Choose a variety which will give best results on rich soils.

Common Faults of Oats

Lodges on rich ground
Yields reduced by hot weather while filling
Is subject to rust and smut
Gives light weight berries when climate and soil are unfavorable

PERCENTAGE OF HULL

A high percentage of hull in oats is usually caused by lodging, heat or drouth. Light weight oats makes poor feed and if used as seed the small shriveled kernels will give the young plant a very poor start in life. The following data are taken from experiments in the department of agronomy:

TABLE II.—PERCENTAGE OF HULL IN TWO VARIETIES

	1913	1914	1915	1916	1917	1918	1919	7-year average
Ped. No. 7	24.11	34.2	27.48	29.99	27.2	29.7	26 59	28 4[illegible]
Ped. No. 1	25.05	34.55	28.05	31 7	28.0	28.22	32.18	29 68

This table shows that a difference of nearly 10 per cent in hull was caused by the season. 1913 gave the lowest and 1914 the highest percentages. The variation between Pedigree No. 7 and Pedigree No. 1 is not so great as the variation found in different years. Seasons do not affect all varieties alike; 1918 gave Pedigree No. 7 a heavier hull than Pedigree No. 1, while 1919 gave Pedigree No. 7 a very light hull and Pedigree No. 1 a comparatively heavy one.

Varieties differ widely in their natural tendency to produce hulls. The Pedigree No. 7 and Pedigree No. 1 have comparatively light hulls, ranging from about 24 to 34 per cent. Some varieties run 10 to 20 per cent heavier. An extreme case was found in 1916 where a variety gave over 50 per cent hull. Table III shows some of the heaviest yields of hull found in 101 tests over a seven-year period:

TABLE III.—STRAINS GIVING HEAVY YIELDS OF HULL

Ped. No. 16	1916	52.81 per cent hull.
Ped. No. 14	1914	48.65 per cent hull.
Ped. No. 15	1914	44.82 per cent hull.
Ped. No. 11	1914	44.23 per cent hull.

Thinness of hull, therefore, is a practical point to keep in mind when selecting a variety of oats to grow.

OAT GROUPS

According to color we have black, white, yellow, gray or dun and red. Some varieties are fall sown, others are spring sown. Some are hulled, some are hull-less. Some are early maturing, some mid-season, and some late. Some have a panicle that spreads in all directions and others have all the kernels hanging on one side.

Fall sown oats are not suited to Wisconsin, as none of the varieties are sufficiently hardy to withstand the winter. Late maturing varieties are adapted to the climate of northern Europe, where the growing season is long and there are no hot spells. In Wisconsin the mid-season varieties are most commonly grown, but the early varieties are becoming very important in the southern and central part of the state.

Most of the varieties of side oats are late maturing. Only two have been found—the White Jewel and White Russian, which are adapted to upper Wisconsin conditions.

VARIETIES FOR WISCONSIN

Swedish Select, Wisconsin Pedigree No. 5

One of the oldest and best known of the oat varieties in Wisconsin is the Pedigree No. 5. This is a pure line selection from the Swedish Select. The original stock from which this selection was made was obtained from the United States Department of Agriculture in 1898. Several selections were made and bred up by the centgener method and finally Pedigree No. 5 was found to be superior to its competitors.

FIG. 2—THE TWO LEADING TYPES OF WISCONSIN PEDIGREE OATS

Left—Wisconsin Wonder, Ped. 1.
Right—State's Pride, Ped. 7.

The kernel is large, white, and plump. The head is large and spreading; the straw grows tall and rank. Where the soil is not too heavily charged with nitrogen and organic matter Pedigree No. 5 yields heavily and stands up well. But it lodges easily on rich soils and hence is not suited to farms maintaining large herds of live stock.

Wisconsin Wonder, Wisconsin Pedigree No. 1

The most popular oat in Wisconsin is the Wisconsin Wonder, Pedigree No. 1. This is a pure line selection from a strain of oats received from a Jefferson county farmer in 1901. It was also bred by the centgener method; and among many competing individuals Pedigree No. 1 was selected.

This oat has a stiffer straw than the Pedigree No. 5, the kernel is also white but more slender. The tables in the appendix show that this oats has the highest average yields of the mid-season varieties, except at Ashland and Spooner. It withstands lodging on rich soils much better than Pedigree No. 5. It is the oat most widely grown in the state.

State's Pride, Wisconsin Pedigree No. 7

Pedigree No. 7, a pure line selection from the Kherson oats, has come into prominence during the last few years. The original stock of this oats was obtained from the Nebraska Experiment Station in 1906. The Nebraska station obtained its lot from the Kherson district in Russia, where the climate is dry and early hardy varieties of oats are grown.

This oats is yellow, small-kerneled, thin-hulled and early. As a rule the straw is fine and does not grow as tall as the Pedigree No. 1 and matures about a week earlier. Owing to its earliness it is one of the best nurse crops. It often escapes rust, heat and lodging. If it lodges it fills out the kernel well. For this reason it is recommended for farms having very rich soils. It is one of the highest average yielders and gave a good crop at Madison the past season (1921), when the mid-season varieties were practically failures.

The small sized yellow kernel of this oats is somewhat objectionable. On light sandy soils, occasionally, it does not grow straw long enough to be cut with the binder.

White Cross, Wisconsin Pedigree No. 19

As small size and yellow color were objectionable features of Pedigree No. 7, an attempt has been made to produce a white oat of larger size than the Pedigree No. 7 and still maintain the earliness and high yield. Several crosses have been made with that end in view. The White Cross, Pedigree No 19, a pure line selection from a cross made in 1911 between the Big 4 (Pedigree

2) and Sixty Day, is showing much promise. The kernel is white, larger than the Pedigree No. 7, is from two to three days earlier, and the yields have been high.

Forward, Wisconsin Pedigree No. 1241

This strain was bred at the Ashland Branch Station from Silver Mine stock. In a seven-year test it outyielded its nearest competitor by five bushels per acre (See Table XIII). It has a white, plump, rather short kernel. The straw is stiff and of medium height. As a yield test is just completed, only a small amount has been disseminated.

White Russian, Wisconsin Pedigree No. 1214, and White Jewel

These are two newer oats which show up favorably in tests at the branch stations. The White Russian is not susceptible to rust and the White Jewel is quite resistant to lodging.

DISSEMINATION

The Experiment Station work with small grains would be of comparatively little value if it stopped after it had produced superior varieties. To be of real help to the farmers these improved strains should reach them with the least possible delay. In Wisconsin this is accomplished through the co-operation of the Wisconsin Experiment Association. Members are entitled to a small amount of the newer superior sorts, and thus, through the large membership, grains are quickly disseminated.

The Experiment Association membership includes farmers in neighboring states and in some foreign countries. Because of the wide distribution of members and the popularity of the best adapted varieties in the state, many acres of Wisconsin pure bred grains are found outside the state.

The Experiment Station has a further advantage in the co-operation of this organization in that it can determine the adaptability of new varieties to varying soil and climatic regions.

All the pure bred varieties of grains have been disseminated through this association. Prospective purchasers may obtain any of these through members or through the different Experiment Stations.

SOILS FOR OATS

Oats yields best on clay or loam soils in a moderate state of fertility. It lodges on rich ground more easily than other small

grain crops. On light sandy soils, oats will give as good returns as any small grain crop except rye.

As rich soils are unsuited for oats, and as many Wisconsin dairy farms have such soil, it is necessary to use varieties which will give best results under this unfavorable environment or to use a rotation which will reduce the fertility, before planting oats.

Rotation for Oats

In general, oats should be placed in the rotation where the least amount of plant food is available. It usually follows corn, or potatoes, both heavy users of plant food.

Where pasture is needed, the following four-year rotation is popular:

Corn
Oats seeded to clover and timothy
Clover hay
Pasture

Stock farms usually are troubled with lodging in oats due to excessive fertility. In good corn-growing localities where farms are equipped to handle large amounts of corn the oats is put in after two successive corn crops.

Corn		Corn
Corn		Corn
Oats	or	Oats seeded to clover and timothy
Clover		Clover hay
		Pasture

The yields after various crops, which are averaged in Table IV for a four-year period, show no striking differences—an indication that oats is quite tolerant, so far as rotation is concerned. The difference between oats after oats and oats after peas is quite marked, while that between oats after corn and oats after oats is much less. The two other crops, barley and rye, were not used for a long enough period to be comparable. In 1920, and again in 1921, oats gave a relatively good yield when preceded by rye. There was less lodging than when oats followed corn or peas.

TABLE IV.—YIELD OF OATS AFTER VARIOUS CROPS—MARSHFIELD STATION

Year	Barley	Corn	Oats	Peas	Rye
	Bu.	Bu.	Bu.	Bu.	Bu.
1918	51.1	60.9	57.8	65.5	----
1919	38.0	39.5	47.1	38.6	----
1920	----	41.7	30.9	49.4	47 2
1921	----	23.8	21.3	21.8	26.5
Average	----	41.5	39.3	43.8	----

Two crops of grain in succession following a crop of corn will serve the same purpose as the rotations given above and will fit the needs of the farmer who prefers to grow more grain than corn. At Conrath and Marshfield this rotation has been found well suited to the growing of oats:

Corn, potatoes or roots
Barley, wheat or rye
Oats seeded to clover and timothy
Clover hay
Pasture

PREPARATION OF THE SEED BED

Where the soil is poor or only moderately fertile the seed bed should be well worked up with the disk or spring tooth and should be worked down fine with a smoothing harrow. In other words, prepare as good a seed bed as is necessary for wheat or barley.

In dairy regions, where much lodging occurs in oats, many farmers disc up the corn ground for oats in the spring without fall plowing. This saves the cost of plowing, but they also claim they have less lodging in oats as a result. This is sound practice. In the first place, oats will stand poorer seed bed preparation than other small grain crops, and in the second place, too much fertility may be liberated by plowing and cultivation where the soil is very rich. Less lodging, therefore, might easily be expected from this practice. (Experiments from the Ohio Research Station bear this out). The great difficulty in such practice, however, is that the ground is likely to become weedy.

DRILLING VS. BROADCASTING

Many farmers on heavy clay lands prefer the broadcaster, while the drill gives best results on light soils. Clay soils

are difficult to work up fine enough for the best results for a drill. When they are worked up fine, if heavy rains occur after seeding, the soil is likely to crust over the seed bed and prevent the emergence of the young plants. In the light soils the main object is to get the grain down deep enough to get plenty of moisture. No hard crust forms to prevent the young plants from emerging.

On the experimental farm at Madison in a six-year test little difference is shown btween drilling and broadcasting. Some years show a slight advantage in favor of drilling and other years show a gain from broadcasting. The six-year average on Wisconsin Pedigree No. 1 oats is 59.9 bushels per acre yield from drilling and 61.5 bushels per acre yield from broadcasting. On the Experimental Farm the ground was thoroughly worked and the grain well covered when broadcasted. It evidently makes little difference which type of seeder is used, provided the grain is properly covered and put where it will receive sufficient moisture.

TABLE V.—DRILLING VS. BROADCASTING—PED. NO. 1 OATS

	Drilled Bu. per acre	Broadcasted Bu. per acre
1916	71.9	77.9
1917	76.9	79.4
1918	57.2	61.6
1919	41.3	38.4
1920	82.1	88.1
1921	26.1	23.8
Six-year average	59.9	61.5

DATE OF SEEDING

For best results, sow oats as early as possible. Late seeding of oats is more apt to suffer loss from rust, lodging and heat damage than early seeding.

Where a piece of ground is prepared late and it is desired to get it seeded down, oats is one of the best crops to plant. In this case the oats should be cut for hay, as there will be little chance of having grain of good quality under such conditions. Rust or lodging is almost sure to injure it if left for seed. Furthermore, the early removal of the crop will be beneficial to the young seeding.

RATE OF SEEDING

The average rate of seeding oats in Wisconsin is 2½ bushels per acre. While the Wisconsin Station has no data on rates of seeding, tests carried on by other stations show that a variation of as much as a bushel per acre may not show much difference in yield. In England sometimes as much as five bushels per acre is sown. On rich soils three bushels per acre will give an increase in yield over 2½ bushels per acre, but it will be very likely to lodge, thus reducing the yield.

When used as a nurse crop, 2 bushels per acre is preferred. This competes less with the young clover plants for food and moisture, offers less shade, and there is less liability of lodging. Lighter rates are also preferable where the variety has small seed.

OATS AS A NURSE CROP

Heavy-leaved late maturing varieties of oats make poor nurse crops because they shade the ground too much and occupy the ground too long, thus draining both fertility and moisture which is needed by the young clover plants. If the oats is cut during hot, dry weather, the sudden exposure of the clover to the hot sun may seriously injure it. The heavier the shading the more severe the injury will be.

The Kherson varieties are superior to other types of oats as nurse crops. Its early maturity and rather small leaf growth make it the equal of any other small grain in this respect.

HANDLING THE CROP

As oats does not shatter easily nor cure as readily in the bundle as wheat or barley, it is usually not cut until fully ripe. It is a mistake, however, to wait until it is over-ripe. Storms may come and cause bad losses through lodging and beating out the grain.

Some prefer the long shock; others prefer the round. The long shock allows more rapid curing and drying and damages the clover seeding less than the round shock. The round shock turns water better; and where the shocks are apt to remain in the field for some time, they should be made round and properly capped.

Unless oats can be threshed just as soon as the shocks are cured and dry, it is better to stack than to allow the grain to

stand in the field to await threshing. The probability of damage from rains is too great to take any unnecessary chances by leaving the grain in the shocks. Shock threshed grain must be given special attention to prevent heating in the bin. Often it must be spread out and turned several times.

SUCCOTASH

Some farmers always grow a little wheat with oats, claiming that they get better results than by growing either of them alone. The Experiment Station at Madison has carried on a test for the past two years of planting Marquis wheat and Pedigree No. 1 oats together in equal amounts by weight. The grain was sown with the drill set at the rate of 2 bushels per acre for oats. In neither year was the wheat attacked by rust, although an adjoining strip of Marquis was badly rusted in 1920. The oats in both years was of better quality than that grown in the other plots. Another interesting fact was that no lodging occurred either year. The possible explanation for these results is that the oats and wheat do not compete as strongly when planted together as when planted alone, and the wheat straw being stiffer than oats helps to keep it from lodging. No explanation can be suggested now for the difference in rust infection.

The average for the two years that this experiment has been carried on shows that "succotash" has outyielded both the Marquis wheat and the Pedigree No. 1 oats in pounds per acre.

TABLE VI.—YIELD PER ACRE IN POUNDS

	Succotash Lbs.	Ped. No. 1 Oats Lbs.	Marquis Wheat Lbs.
1920	2530.8	2614.4	1242
1921	1232	787.2	1122
Average	1881.4	1700.8	1182

In 1920, which was a particularly favorable season for oats, the Pedigree No. 1 oats outyielded the "succotash," but in 1921, which was a very poor season for oats, the "succotash" outyielded the oats. This test will be continued, as a two years' test is too short to reach conclusions.

It is obvious that wheat and oats cannot be sown together if either is to be sold for pure bred seed, as they cannot be completely separated by any fanning mill on the market.

A GOOD CROP OF OATS IS A

STATE'S PRIDE OATS AND VARIETY TEST

URCE OF PRIDE AND PROFIT

OTS AT MADISON EXPERIMENT STATION

OAT DISEASES

Oats has two diseases which cause considerable damage—rust and smut The rust that attacks oats is a different species from that which attacks wheat. The wheat rust will not attack oats and the oat rust will not attack wheat. No practical control of oat rust has been found. Treatments which will kill the rust spore will kill the seed. The Red Rust Proof oats, which is grown as a winter oat in the South, shows considerable resistance to rust, but this variety is not adapted to northern conditions. Few of the northern varieties of oats have any marked resistance to rust, although White Russian is one that has.

The damage from oat smut may become very serious if allowed to go without attention. One sample of seed was sent to the Wisconsin Station three years ago that produced fully 95 per cent of damage in the resulting crop. Both the loose and covered smuts of oats can be entirely eradicated by the formalin treatment.[3] Make up a solution of 1 pint formalin to 30 gallons of water. Dip the grain or use a good smut machine that wets every kernel thoroughly with the solution. If the work is done carefully and all sacks and other containers treated, it probably will not be necessary to treat again for three or four years.

USE THE FANNING MILL

Always fan and grade the seed oats. The large heavy kernels are always to be preferred for seed, as they have a large store of plant food and will give strong vigorous plants. Small shrunken endosperms are not readily detected in oats. Often the hull develops nearly to normal size and the meat on the inside is very small and shrunken. These will give a very weak germination and the resulting plants will lack vigor and will not survive if the season is unfavorable. The result will be a very poor stand and a low yield. It is clearly evident then, that such seeds should be cleaned out and used for feed.

It is worth while to use the fanning mill, if for no other reason than to clean out the chaff and bits of straw in the grain. Oats clogs in the seeding machinery rather easily and a small amount of trash in the seed may cause much inequality in the seeding.

[3] *Fight Grain Smuts and Blights*, Wis. Agr. Exp. Sta. Circular 57.

VARIETY TESTS

One of the objects of the Experiment Station is to try out all the varieties offered or advertised on the market in comparison with standard varieties. Often great claims are made for a new strain of grain and a high price put on it. So far no advertised variety has been found which is superior to Wisconsin improved pedigree stocks. Some have proved very good but in many cases it is very evident that some of the best yielding varieties have been renamed and resold at an advanced price. These often are excellent yielders and in many cases are competing with those of their own kind. As an illustration of the confusion, Etheridge[4] reports 138 names for Swedish Select oats.

FIG. 3.—PLOT THRESHING ON UNIVERSITY EXPERIMENTAL FARM
Small plots are used to determine yields. After each variety is threshed the threshing machine must be cleaned carefully. The grain is weighed, scaled and sacked separately.

Variety tests on oats were begun at the Experiment Station at Madison in 1898. Reports on the results of the earlier tests will be found in the annual reports of the Agricultural Experiment Station up to and including the 24th annual report.

The tables in the appendix show the comparative yields in the variety test plots, but do not show all the varieties under test either at Madison or at any of the branch stations.

[4] Cornell University Memoir 10.

In many cases a variety was discarded after a one or two-year test. Others were carried farther but later thrown out. Hundreds of new selections have been produced, and several of them reached the test plots but were later discarded. All such yields have not been reported in the appendix, as they add no valuable information and would needlessly encumber the tables. The tables in the appendix are not an exhaustive report of the Experiment Station's variety test work in oats, but rather a compilation of results which may be helpful.

The size of the test plots where yields have been obtained were 1/20 or 1/40 of an acre. Since 1916 all varieties have been grown in duplicate. The different varieties have been grown side by side on ground as nearly uniform as possible. The standard pedigrees are grown each year as a standard for comparison of all other varieties.

The following table shows the seven best yielders for the past four years. The first four belong to the Kherson type, State's Pride having a comfortable lead; 1921 brings down the average of the medium early white oats and makes the Kherson oats stand out prominently.

TABLE VII.—SEVEN BEST VARIETIES OF OATS (GROWN AT MADISON OVER FOUR-YEAR PERIOD—1918-21)

Variety	Average yield per acre
State's Pride, Ped. No. 7	66.1 bu.
Golden Rust Proof	61.5 bu.
Iowa 105	59.0 bu.
Iowa 103	58.6 bu.
Wisconsin Wonder, Ped. No. 1	57.4 bu.
Gold Mine	53.1 bu.
White Cross, Ped. No. 19	52.2 bu.

VARIETY TESTS AT ASHLAND

Improvement and breeding work at the Ashland Station was started in 1908, but no variety tests were made previous to 1912. Work under very similar climatic and soil conditions, however, was done at Superior beginning with 1908, and continued until 1912. Selections from the best yielding varieties were made at Superior in 1911 and planted in nursery rows at Ashland in 1912. All told, some 200 selections were planted. From these a few pedigree strains were retained and put in the regular variety test. At Ashland the very early types, such as Kherson and Early Daubeney, were dropped out because of low yield and poor quality.

FIG. 4.—PEDIGREE NO. 1289 OATS AT SUPERIOR

This oats yields over 80 bushels an acre.

In the appendix are the yields for all varieties which were under test. The following table is a nine-year average of the best yielders. Results show that Forward, Pedigree No. 1241, has a decided lead. This variety is most worthy of dissemination in the upper section of the state.

TABLE VIII.—NINE BEST YIELDERS AT ASHLAND STATION (AVERAGE FOR NINE YEARS, PURE LINES FOR THE LAST FIVE YEARS)

Variety	Average yield per acre
Forward Ped. No. 12.41	55.9 bu.
Wisconsin Wonder, Ped. No. 1	51.7 bu.
Early Gothland, Ped. No. 4	50.9 bu.
Giant Swedish, Ped. No. 12.128	50.4 bu.
White Russian, Ped. No. 12.14	49.7 bu.
Irish Victor, Ped. No. 12.89	47.5 bu.
Swedish Select, Ped. No. 5	46.8 bu.
White Jewel, Ped. No. M-13.16	44.6 bu.
White Jewel, Ped. M-132	41.4 bu.

VARIETY TESTS AT MARSHFIELD

Variety work with oats at the Marshfield Station was begun in 1912. Owing to poor drainage conditions, the results for that year are not included as they are not comparable between varieties. In 1917 and 1918, owing to faulty labor conditions, some of the oats were mixed and others not threshed, thus breaking the continuity of the work. Beginning with 1920 a new seed supply was sent from Ashland and Spooner.

Results have been very unsatisfactory for these reasons and recommendations of varieties are made with reservations. Pedigree No. 1, Pedigree No. 3 and Pedigree No. 4, however, are recommended because of their good yield and considerable resistance to lodging.

FIG. 5.—THE NEW IMPROVED VARIETIES ARE GIVEN CAREFUL STUDY IN ROWS

After observation and careful study the superior or promising varieties are selected for further testing in plots.

TABLE IX.—SEVEN BEST YIELDERS AT MARSHFIELD
(FIVE-YEAR AVERAGE—1917-21)

Variety	Average yield per acre
Wisconsin Wonder, Ped. No. 1	50.6 bu.
Tobolsk, Ped. No. 3	48.2 bu.
Early Gothland, Ped. No. 4	46.7 bu.
White Russian, Ped. No. 1214-A	46.7 bu.
State's Pride, Ped. No. 7	46.5 bu.
Swedish Select, Ped. No. 5	45 6 bu.
Irish Victor, Ped. No. 1289-A	43.5 bu.

VARIETY TESTS AT SPOONER

Work with oats was begun at Spooner in 1912, with 26 varieties, three of which were pure lines. Selections were made the same year and a breeding nursery was put in in 1913, containing

FIG. 6—BREED OATS THAT DO NOT LODGE READILY.
Some strains of oats do not lodge as easily as others. Pedigree No. 1241 and White Jewel were found to be the best for the Lake Superior district.

some 400 different pedigrees. A few of the most promising were continued and compared with standard kinds and with pedigree strains from various sources. Table XIV in the appendix shows results for each year and for five-year averages. Table X shows average yields for nine years for pure lines and for pure lines with the parent variety. Medium early varieties gave the best results but very early kinds did not average as well.

TABLE X.—TEN BEST YIELDERS AT SPOONER STATION (AVERAGE FOR NINE YEARS, PURE LINES FOR THE LAST FIVE YEARS)

Variety	Average yield per acre
Silver Mine, Ped. No. S-13405	36.9 bu.
Big Four, Ped. No. S-1316	36.8 bu.
Early Gothland, Ped. No. 4	35.4 bu.
Wisconsin Wonder, Ped. No. 1	35.1 bu.
Scottish Chief, Ped. No. S-13325	34 7 bu.
Black Finnish, Ped. No. S-1300	33.3 bu.
Swedish Select, Ped. No. 5	33.1 bu.
Tobolsk, Ped. No. 3	32.8 bu.
Silver Mine, Ped. No. 8	32.5 bu.
Kherson, Ped. No. 7	31.5 bu.

TABLE XI.—VARIETY TESTS OF OATS AT MADISON STATION

	1911	1912	1913	1914	1915	1916	5 Yr. Av. 1911-15	5 Yr. Av. 1912-16
Wisconsin Wonder, Pedigree No. 1	56.2	110.6	75.6	63.7	90.0	71.9	79.22	82.4
State's Pride, Pedigree No. 7		80.4	65.0	67.4	111.8	69.7		78.8
Swedish Select, Pedigree No. 5	47.5	74.3	54.3	49.4	58.7	64.5	56.8	60.2
Joannette Wisconsin 56	36.2	93.1						
White Tartar Wisconsin 46	51.2	89.6						
Early Gothland, Pedigree No. 4	47.0	86.2						
Big Four, Pedigree No. 2	60.8	91.2	73.7					
Golden Drop Wisconsin 91	51.2	84.3	68.1					
Daubeney Wisconsin 2	52.5	91.2	55.0					
Emperor William, Wisconsin 73	52.5	94.3	63.1					
Old's Large Yellow Wisconsin 92	55.6	103.1	72.7					
Garton 784 Wisconsin 87	39.3	83.1	60.0					
Garton 436 Wisconsin 70	45.6	90.6	71.2					
Salzer's Great Northern Wis. 74	46.8	73.1	60.0					
White Plume Wisconsin 101	43.1	81.8	47.5					
Garton 364 Wisconsin 66	55.6	103.1	72.7					
Hunt Wisconsin 90	42.5	104.2	74.3	59.4				
Salzer's Reg. White Bonanza Wisconsin 86	45.0	80.0	68.1	49.3				
Salzer's National Wisconsin 72	43.7	67.5	61.8	50.0				
Beseler Wisconsin 94	45.6	100.0	70.0	40.6				
Reg. Swedish Wisconsin 93	45.0	86.2	60.6	42.4				
Fichtel Mountain Wisconsin 96	50.0	72.5	61.2	43.0				
S. P. I. 25750 Wisconsin 98	48.7	65.6	67.3	40.0				
Green Mountain Wisconsin 81	57.5	91.2	74.3	65.6	91.8	73.4	76.1	79.4
Minn. 6 Wisconsin 22	58.7	86.8	73.1	50.0	89.3	70.0	71.6	73.8
Northrup King & Co. Wisconsin 50	46.8	93.7	73.7	61.2	90.6		73.2	
Texas Red Wisconsin 20	42.5	71.2			91.8	48.6		
White Bedford Wisconsin 17	53.7	93.1	75.6	64.0	97.5		76.8	
Sixty Day, Pedigree No. 6	51.2	64.0	61.8	55.0	86.2		71.5	
American Banner Wisconsin 36	40.6	86.4	58.0	62.4	53.4	51.9	66.2	62.4
S. P. I. 25749 Wisconsin 99	46.8	90.6	60.0	63.0	93.1		70.7	
20th Century, Pedigree No. 11		82.0	79.3	56.2	91.8	58.1		73.5
Golden Fleece, Pedigree No. 12		82.4	78.7	64.8	54.3	66.7		69.4
Garton 466, Pedigree No. 13		97.3	70.6	56.6	90.0	75.3		77.8
Garton 585, Pedigree No. 14		66.0	58.1	54.3	81.8	64.2		64.9
Garton 473, Pedigree No. 16		79.2	56.2	55.9	61.2	51.9		60.9
Garton 453, Pedigree No. 15		55.6	57.5	34.7	36.2	56.1		48.0
Silver Mine, Pedigree No. 8		61.4	80.0	37.4	75.0	69.7		64.7
Belyak, Pedigree No. 10		69.2	68.7	56.8	89.3	73.7		62.4
Scottish Chief Wisconsin 129				48.7	90.6	80.0		

TABLE XII.—VARIETY TESTS OF OATS AT MADISON STATION

	1915	1916	1917	1918	1919	1920	1921	5 Yr. Av. 1915-19	5 Yr. Av. 1917-21	4 Yr. Av. 1918-21
Wisconsin Wonder, Ped. 1	90.0	71.9	65.4	61.6	61.6	81.7	24.6	70.1	59.0	
State's Pride, Ped. 7	111.8	69.7	75.6	82.8	52.8	82.0	46.9	78.5	62.0	
Swedish Select, Ped. 5	58.7	64.5	68.3	64.1	37.5	53.8	21.7	58.6	49.1	
White Shonen, Wisconsin 127	80.6	81.4	58.1	62.5						
Scottish Chief, Wis. 129	90.6	80.0	68.2	67.8						
Tartar King, Wis. 128	56.8	64.3	57.5	65.6	35.5			55.9		
Irish Victor, Wis. 107	83.1	77.2	62.5	66.9	34.0			64.7		
Improved American, Wis. 108	81.8	87.7	62.5	57.5	44.7			66.8		
Victory, Svalof, Wisconsin 103	81.8	90.6	62.5	63.1	35.3			66.7		
N. Austria, Wis. 117	76.4	81.1	48.7	64.3	37.7			61.6		
Banner Wis. 106	87.5	71.6	63.8	65.6	28.1			63.3		
Fourth of July, Wis. 102		50.3	62.5	58.4						
Ashland 1241		66.1	73.1	62.8	40.0	55.3	28.5		51.9	
Ashland 12.89		66.3	49.7	63.5	36.9	64.1	25.1		48.1	
Red Russian Wis. 130		81.5	69.4	66.2	42.0	64.1	26.0		53.5	
Tobolsk Ped. 3			65.0	55.0	34.4	39.9				
Iowa 103, Wisconsin 133			75.0	71.6	49.4	58.2	55.3		61.9	
Iowa 105, Wisconsin 134			69.4	77.2	40.6	63.1	53.2		60.7	
Golden Rust Proof Wis. 136				77.0	51.3	63.7	54.0			61.5
Gold Mine Wis. 148				72.8	45.0	62.5	31.9			53.1
Russia 304, Wis. 138-11				72.2	32.4	55.5	20.0			45.0
Russia 304, Wis. 138-10				70.0	38.6	61.9	20.1			47.7
Russia 304, Wis. 138-5				66.3	41.1	64.4	19.4			47.8
Russia 304, Wis. 138-6				63.7	36.1	63.7	19.4			45.7
Russia 304, Wis. 138-4				60.6	39.4	53.4	20.9			43.8
Russia 304, Wis. 138-7				62.2	32.3	61.8	21.4			44.4
Record Wis. 143				66.2	37.4	44.1	20.4			42.0
Yielder Wis. 145				65.0	37.8	58.4	30.3			47.9
Minn. 512, Wis. 150				64.1	45.0	51.6	23.6			46.1
Swedish Crown Wis. 131				60.7	42.0	78.4	21.3			50.6
Swedish Victory Wis. 132				59.0	34.7	60.9	18.6			43.3
Garton Wis. 140				57.2	38.0	57.8	23.8			44.2
Green Mt. Favorite Wis. 135				57.2	35.2	43.7	21.6			39.4
New Victory Wis. 151				56.2	30.0	51.3	25.0			40.6
Ped. 19 White Cross				54.1	45.6	67.2	41.9			52.2
Ped. 18				47.6	44.9	71.2	42.9			51.6
Ped. 17				54.1	47.8	74.4	32.9			49.8
Canadian Wis. 149				46.6	25.6	34.1	20.4			31.7
Sparrow Bill Wis. 142				43.1	24.7	41.3				
B. H. 11, Wis. 154					51.1	78.2	27.6			
B. H. 5, Wis. 154					47.6	67.5	57.5			
Berry's New Sensation Wis. 137					44.8	66.6	52.9			

TABLE XII.—(Continued)

	1915	1916	1917	1918	1919	1920	1921	5 Yr. Av. 1915-19	5 Yr. Av. 1917-21	4 Yr. Av. 1918-21
Silver Mine Wis. 158					41.1	50.3	28.8			
Lincoln Wis. 157					40.5	47.8	22.2			
Irish Victor Wis. 156					35.5	51.9	26.6			
Garton Wis. 141					34.2	51.3	24.3			
New Victory Wis. 159					33.9	53.4	26.1			
Early Yellow Wis. 164						73.4	22.2			
Gold Mine Wis. 174						67.3	34.4			
Golden Sheaf Wis. 161						61.6	40.7			
Great Dane Wis. 166						61.3	20.5			
Royal Prince Wis. 163						59.9	16.9			
Great Dane Wis. 162						55.9	20.6			
Quaker Wis. 175						52.2	26.6			
Granary Filler Wis. 165						41.6	31.3			

TABLE XIII.—TEST OF OAT VARIETIES AT ASHLAND BRANCH STATION, 1909-1921

Variety	1909	1910	1911	1912	1913	1914	1915	1916	1917	1919	1920	1921	5-year av'rage 1909-13	7-year av'rage 1914-21
White Jewel	66.0	40.8	49.9	25.6	23.4								41.1	
Scottish Chief	54.6	59.7	49.9	25.6	23.4								46.9	
White Marvel	56.2	37.5	59.4	26.1	38.3								43.5	
Golden Cluster	47.8	42.0	56.6	30.7	44.0								44.2	
Ligowa	49.2	37.1	53.9	34.7	41.2								43.2	
Black Egypt	56.0	61.6	43.5	27.6	39.0								45.5	
Early Daubeney	50.0	27.1	63.8	33.0	35.5								41.9	
Lincoln		47.5	50.6	23.6	00.0									
Reg. White Bonanza	58.0	51.3	52.9	30.4	42.6								47.0	
White No. 156	66.8	45.3	49.9	28.1	36.9								45.4	
Tartar King	54.3	48.0	54.4	32.4	38.3								45.5	
Irish Victor	45.3	54.1	52.5	19.3	48.3								43.9	
Black Finnish	52.2	45.3	55.9	29.0										
Early Champion	36.0	26.6	54.0	21.9										
Early Surprise	46.6	57.6	55.1											
White Russian	48.0	59.4	61.9	00.0										
Black Jeanette	44.0	44.7	60.8	30.7										
Black Tartarian	36.0	46.9	37.0											
New Swedish	64.0	54.4	50.6	21.3										
Banner		55.2	61.9	00.0										
Wisconsin Wonder Ped. No. 1					83.8	*19.5	69.0	52.5	51.3	54.1	73.8	31.6		50.3
Big Four Ped. No. 2		56.6	57.4	44.3	80.3									
Swedish Select Ped. No. 5	59.3	41.3			62.5	*19.5	57.0	49.7	43.1	55.6	81.3	28.8		47.9
Kherson Ped. No. 7		33.8	57.4	30.4	62.5						62.2	26.1		
Silver Mine Ped. No. 8			50.8	30.1	75.3									
Early Gothland Ped. No. 4			60.0	28.7	66.8	*19.5	66.8	44.6	51.7	57.8	88.4	34.0		51.8
20th Century Ped. No. 11	55.0	47.8	49.5		57.5									
White Jewel Ped. No. M-13.2A						24.8	75.8	36.7	43.7	50.9	71.3	20.5		46.2
Silver Mine Ped. No. 12.41A						28.1	79.0	55.5	60.0	55.6	80.0	39.3		56.8
Giant Swedish Ped. No. 12.128A						27.6	80.8	36.8	54.7	46.9	82.9	32.7		51.8
White Russian Ped. No. 12.14A						27.1	81.8	33.8	54.4	45.5	83.8	21.0		49.6
Big Four Ped. No. 12.31						20.7	74.0	53.8	64.1					
Irish Victor Ped. No. 12.89A						30.4	68.5	50.9	41.5	55.6	81.0	31.7		51.4
Irish Victor Ped. No. 12.81						27.6	61.0	54.6	42.5					
Giant Swedish Ped. No. 12.130						26.8	81.3	38.6						
White Jewel Ped. No. M-13.16A						33.9	72.5	46.6	50.0	55.0	71.3	23.5		50.4
Minn. No. 295									59.0		80.4	31.4		
Minn. No. 261									53.7	64.7	52.5	21.9		
Pedigree No. 17										63.1	70.9	27.2		
Pedigree No. 18										60.6	65.7	23.5		
Pedigree No. 19										59.6	63.8	21.9		
Pedigree No. 16.76												27.4		
Common												29.3		
Ped. No. A-16.83												31.7		
Ped. No. A-36.15												28.3		

Note: Variety test not made during 1918 on account of war.
Used same yield for varieties marked (*) in order to make comparison more equitable. (1914)

TABLE XIV.—TEST OF OAT VARIETIES AT SPOONER STATION, 1912-1921

Variety	1912	1913	1914	1915	1916	1917	1919	1920	1921	5-year average 1913-17	5-year average 1914-19	5-year average 1916-21
Early Daubeney	11.8	24.6	48.3	29.5								
Golden Cluster	7.0	29.5	40.5	52.5								
Kherson	15.8	23.0	43.9	00.0								
White Jewel	11.0	26.3	33.5	45.0								
Early Gothland Ped. No. 4	13.5	27.5	39.5	57.2	34.4	50.5	40.0	51.0	4.7	41.8	44.3	36.1
Tobolsk Ped. No. 3	11.0	27.0	42.0	50.0	33.8	51.8	35.0	41.5	2.8	40.9	42.5	33.0
Big Four Ped. No. 2	15.0	34.8	36.0	48.6	37.8	57.6				43.0		
Scottish Chief	14.5	29.8	37.0	42.0								
Silver Mine	13.0	25.0	33.4	46.0								
Lincoln	9.3	31.5	37.1	38.5								
Black Tartarian	13.5	34.0	39.0	47.0								
Giant Swedish	15.8	35.5	25.7	32.0								
White Russian	21.3	34.3	33.7	55.0								
Black Finnish	8.5	30.5	52.5	42.3								
Swedish Select Ped. No. 5		24.8	38.8	51.5	38.1	47.5	39.5	40.0	4.7	40.1	43.1	34.0
Wisconsin Wonder Ped. No. 1			41.5	55.2	37.5	46.8	38.0	54.0	2.5		43.8	35.8
Kherson Ped. No. 7			52.8	38.0	34.4	42.7	37.3	29.0	9.8		41.0	30.6
Silver Mine Ped. No. 8			42.3	57.0	22.5	51.5	32.8	45.5	3.3		41.2	31.1
American Banner Ped. No. 9			41.1	49.3	35.0	57.2						
Belyak Ped. No. 10			31.7	49.3	25.6	54.9	26.2					
20th Century Ped. No. 11			34.0	43.0	40.9	48.7					37.5	
Golden Fleece Ped. No. 12			37.0	40.5	42.8	45.5						
Big Four Ped. No. 13.16					38.1	56.8	41.9	52.0	7.5			39.4
Garton No. 585 Ped. No. 14			53.5	44.8	40.3	50.0	18.7				41.5	
Tartar King No. 13.130					21.9	48.4	35.7	46.0	4.5			31.3
White Marvel No. 13.303					23.1	50.0	35.0	43.5	3.8			31.1
Black Finnish No. 13.00					32.2	52.7	36.9	38.0	6.3			33.2
Banner No. 12.165					28.8	48.0	28.4	50.0	0.0			31.0
Scottish Chief No. 13.325					35.6	58.7	40.0	51.5	3.0			37.8
White Jewel No. 13.255					24.1	48.7	32.2	40.0	2.3			29.5
Lincoln No. 13.280					24.1	57.7	32.6	42.5	3.3			32.0
White Russian No. 13.84					30.9	46.2	24.7	47.5	0.0			29.9
Silver Mine No. 13.405					34.4	61.8	40.7	51.5	6.0			38.9
Pedigree No. 17									6.0			
Pedigree No. 18									6.8			
Pedigree No. 19									10.0			

TABLE XV.—TEST OF OAT VARIETIES AT MARSHFIELD, 1913-1921

Variety	1913	1914	1915	1916	1917	1918	1919	1920	1921	5-year average 1913-17	5-year average 1915-19	5-year average 1916-20	5-year average 1917-21
Early Gothland Ped. No. 4	73.3	10.0	73.5	38.4	43.0	73.8	35.1	66.2	15.3	47.6	52.8	51.5	46.7
Tobolsk Ped. No. 3	69.8	11.3	53.7	32.0	45.6	72.5	37.5	64.9	20.5	42.5	48.3	50.5	48.2
Big Four Ped. No. 2	68.1	10.6	73.5	34.0	52.5					47.8			
Wis. Wonder Ped. No. 1	70.8	11.3	66.8	36.0	55.4	81.3	35.1	68.8	12.2	48.1	54.9	55.3	50.6
White Jewel	71.0	6.9	53.2	36.0									
Scottish Chief	72.8	10.6	67.0	47.0									
Silver Mine	75.0	10.0	56.5	54.0	47.2					46.6			
Swedish Select Ped. No. 5	55.0	12.5	72.5	34.0	47.8	59.1	39.4	68.8	12.7	44.4	50.6	49.8	45.6
Kherson Ped. No. 7			63.3	57.0	43.1	70.0	37.5	61.1	20.8		54.2	53.7	46.5
Silver Mine Ped. No. 8			63.0	41.0	45.6	74.4							
Golden Fleece Ped. No. 12			52.8	40.0	54.5	81.3							
Golden Cluster			60.0	37.5	39.0								
20th Century Ped. No. 11			65.5	42.5	44.1								
Lincoln			44.3	45.5	43.7		27.6						
Roosevelt			55.5	37.5	46.2	76.9	37.5				50.7		
White Russian Ped. 12.14A				32.5	43.1	63.8	39.4	68.8	18.2			49.5	46.7
Irish Victor Ped. 12.89A				36.0	47.4	60.0	35.0	58.5	16.5			47.4	43.5
White Russian Ped. 12.128A				40.0	36.3			67.5	20.5				
White Jewel Ped. 13.2M				45.0	33.8	65.4	26.2	61.1	13.0			46.3	39.9
Silver Mine Ped. 12.41							36.9		20.9				
Ped. No. 17								69.5	15.0				
Ped. No. 19								51.6	16.0				
Ped. No. 18								58.1	18.1				
White Jewel Ped. 13.255s								67.1	13.2				
Big Four Ped. 13.16s								77.8	19.6				
Black Finnish Ped. 13.00s								43.9	4.3				
Lincoln Ped. 13.280s								76.6	13.2				
Silver Mine Ped. 13.405s								77.4	18.4				
Scottish Chief Ped. 13.325s								69.9	11.8				
Banner Ped. 13.165s								69.2	21.3				
White Russian Ped. 13.84s								63.2	19.0				
Common									18.2				

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THE USE OF FERTILIZERS ON DAIRY FARMS

AGRICULTURAL EXPERIMENT STATION
OF THE UNIVERSITY OF WISCONSIN
MADISON

DIGEST

Heavy yields will produce the largest profits under present conditions. Pages 3-4.

More clover and other legumes are needed for feed and to increase the nitrogen in the soil. Page 5.

Phosphorus and lime are the elements most needed to supplement manure for all crops. It increases the yield of all crops—especially clover and alfalfa. Pages 6-14.

The best method of using phosphate on most dairy or general farms, is by the regular use of 300 pounds of 16% acid phosphate or 100 pounds of 44% treble superphosphate per acre on all grain land being seeded to clover. Pages 15-16.

Potash is not generally needed except on peat or muck soils and for certain crops such as potatoes, tobacco, sugar beets, and cabbage. Page 17.

Mixed fertilizers cost about $10 per ton more than the plant food they contain costs in separate forms. Page 18.

Lime is needed by all plants, but especially by clover, alfalfa, beets, peas and barley. Page 19.

Acid soils contain lime and usually supply enough for very good yields of most crops including clover for a number of years after first cleared and broken. Page 20-22.

Older soils usually need lime except some of those in the southeastern part of the state. Field trial is the only known way of determining the need of lime with certainty, but acid soils which have been cropped 15 years or more practically always need lime. Page 23.

Conserve the value of manure by handling it carefully. Use enough bedding to absorb the urine, which contains a large part of nitrogen and potash, and do not let it be leached out by long exposure to rain. Pages 24-25.

The Use of Fertilizers on Dairy Farms

A. R. Whitson and Griffith Richards

THE BARNYARD MANURE produced on Wisconsin livestock farms has done much to maintain the crop-producing power of the soils of the state. In the past it has been practically the only form of fertilizer used by Wisconsin farmers, but the supply is not large enough on most farms to produce maximum yields. Barnyard manure, moreover, is not a well-balanced fertilizer for most soils or crops, and should be supplemented with a phosphate fertilizer and lime to secure the best results.

The cost of raising crops has increased during the past few years to such an extent that farmers will be forced to increase their yields per acre in order to make any profits. It may be necessary, therefore, to give barnyard manure some assistance if the soils are to be built up and maintained in a highly fertile and productive condition. It is true that the soils have been robbed of some of their original store of plant food and that they do lack some of the elements essential for highest crop production.

The yields of all staple crops grown in western Europe before the war were about double the average yields of these crops in the United States. Some of this crop increase is due to better tillage methods, but it is largely due to the more general use of commercial fertilizers. Practically every farmer in England, France, and Germany uses phosphates—often potash and occasionally nitrogen, while the use of lime is a general practice.

Wisconsin farmers are certain that their soils are deficient in plant food elements which must be purchased and applied to their fields. As a result they are actively interested in agricultural limestone and commercial fertilizers. It is very important, however, that farmers select the fertilizers best adapted to the needs of their particular soils and that they be properly applied.

INFLUENCE OF SOIL FERTILITY ON QUALITY OF CROP

The composition of a crop may vary with the fertility of the soil on which it is grown. The old method of measuring the value of a feed was by determining the amount of protein, carbohydrates, and fats it contained, but it has been discovered recently that the mineral constituents in the crop must also be considered. Feeds with high lime and phosphorus contents are especially valuable for building up a good bone framework for the animals. These elements must be in the soil in sufficient amount and available form to be taken up by the plant.

Farmers should recognize that the maintenance of a high standard of fertility means not only large crop yields, but also a better quality of feed for use, especially in growing young animals. It may be difficult to put a definite valuation on this benefit, but there is little doubt that it is of great importance. The best breeders of livestock in Europe and in this country now recognize the importance of supplying the growing animals with an abundant supply of minerals in the feeds or as a supplement to the feeds.

ELEMENTS NECESSARY FOR PLANT GROWTH

The thousands of plants growing on the earth are made up largely of only ten chemical elements. Of these ten, six are generally found in sufficient quantities in soils. The other four elements, nitrogen, phosphorus, calcium or lime, and potassium are likely to be deficient. The farmer who plans to maintain the fertility of his farm will be concerned mainly with these four elements. He, therefore, will want to know what part each plays in the development of plants and what are the best methods of maintaining an adequate supply of these elements.

NITROGEN

Nitrogen is chiefly responsible for the dark green, healthy color and rapid growth of corn or other crops on well-manured land. It seems to regulate the general growth of the plant. The amounts of the other elements of plant food used by a crop are determined by the amount of nitrogen within reach of the crop, consequently it is extremely important to have an adequate supply of nitrogen for the crop at all times.

While it is important to have sufficient nitrogen in a soil, excessive amounts are detrimental for some crops. The quality of grain may be seriously injured by too much nitrogen. The grain may weigh less per bushel, due to lodging of the straw and poor filling of the kernel. Excessive use of nitrogen by growing crops may also make them less resistant to attacks of fungous diseases.

Legume Crops Maintain Nitrogen In Soils

Virgin soils contain large amounts of nitrogen in the vegetable or organic matter, but if they are cropped continuously to such crops as corn, oats and timothy without the addition of fertilizing materials containing nitrogen, the nitrogen supply is gradually exhausted and crop yields are reduced.

Some crops are able to gather nitrogen from the air and add it to the supply in the farm. The clovers, alfalfa, peas and beans have bacteria closely associated with them on their roots that take the free nitrogen from the air and fix it in the plant roots. This is a cheap method of obtaining nitrogen and one which farmers should use to the fullest extent. On the ordinary dairy farm at least one-fourth of the land under cultivation should be seeded to clover or alfalfa. If this is fed to livestock and the manure carefully returned to the land, the nitrogen supply will be gradually increased. If not enough livestock is kept on the farm to require the use of one-fourth of the land in clover, because some land is in cash crops, the legume crop can still be used to add nitrogen to the soil by plowing it under as a green manuring crop. In this case all of the nitrogen in the crop is left in the soil and becomes available to other crops gradually, as they need it. The amount of clover grown on an acre during a year costs only the price of seed and the rental value of the land, which would total from $12 to $15 an acre. It will add from 100 pounds to 125 pounds of nitrogen, however, which would cost in commercial fertilizers from $20 to $25. The clover will also add a large amount of organic matter which is valuable in other ways. Clover or other legume crops should be used as the chief source of nitrogen on most of the livestock farms in Wisconsin. In a few special cases it may be desirable to use a commercial form of nitrogen fertilizer.

The growing of clover or other legume crops is the starting point in the up-building of soil fertility, but it should not be forgotten that clover as well as all growing crops require phosphorus, potassium and lime in addition to nitrogen.

HOW TO GROW CLOVER SUCCESSFULLY

Seed clover on each field regularly every third or fourth year.

Purchase the best clover seed and use plenty of it. Reduce the amount of timothy seed in the mixture and replace with clover seed.

Prepare a fine seed bed.

See that the soil is well supplied with available lime.

Apply 16 per cent acid phosphate at the rate of 300 to 400 pounds or 100 pounds of treble superphosphate an acre to the small grain when seeding down to clover.

Use barley and rye for nurse crops when possible and seed lightly.

If the grain lodges badly or if the season is very dry cut the nurse crop for hay.

Top dress the new clover seedings with a light coat of manure in the fall.

New clover seedings should never be pastured in the fall or spring.

Lay definite plans to grow a good crop of clover.

THE NURSE CROP OFTEN KILLS THE CLOVER

Many farmers report difficulty in getting a good catch of clover and complain of the small yields even when the stand is good. The chief reason for poor results with clover in general probably lies in the fact that many people think that since clover can secure its nitrogen from the air it has no other special needs. It is, therefore, sown with a grain crop, which often takes most of the moisture that the clover should have as well as the other elements of plant food necessary to give it a good start. Clover needs phosphorus and lime as well as a good supply of moisture

and must also have a reasonable amount of light for growth. We call a heavy crop of oats which is grown with the clover seeding a nurse crop, but as a matter of fact it is very far from being a nurse. It actually uses a large part of the available plant food and water which the clover needs. Clover is one of the most valuable crops we can grow and it is worth while to make the effort necessary to give it a real chance.

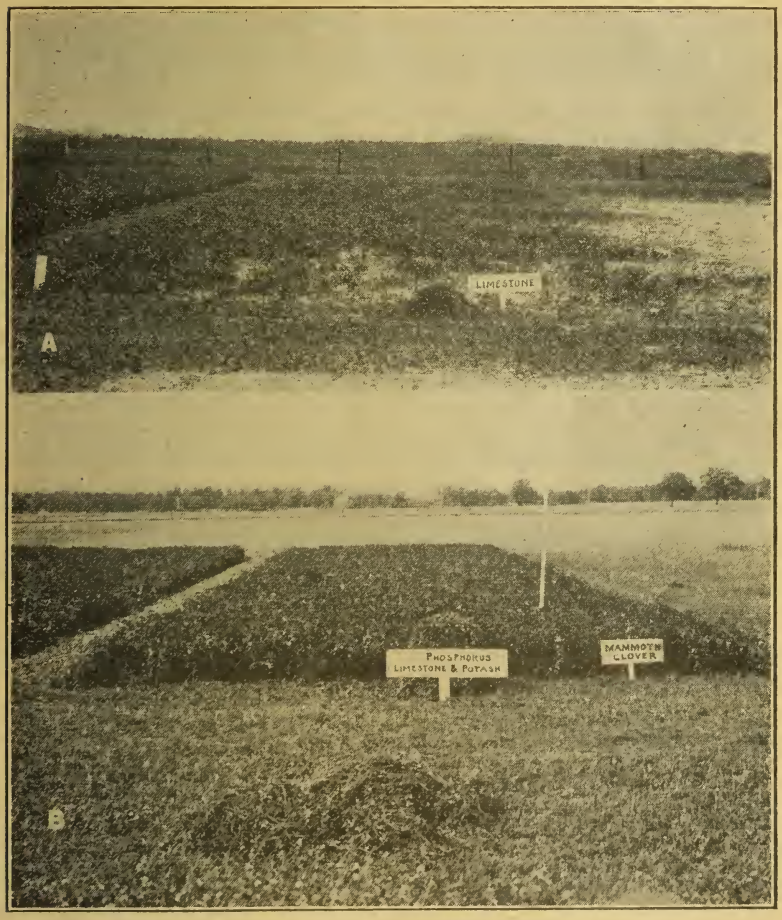

FIG 1.—EFFECTS OF USE OF FERTILIZER

A—A poor sandy soil at Sparta. On right of picture clover failed to grow. Lime produced some clover, but it must be used in connection with other plant foods.

B—Another plot on the same field. The plot at the right received no fertilizer and no clover was the result. The center plot produced 3800 lbs. clover when lime, phosphorus and potash were applied.

Barley is a better nurse crop than oats because it shades the ground less and is cut earlier, but a thin seeding of early oats will usually permit a good catch of clover if the soil is in a fair state of fertility. If the oats threatens to be too heavy and so to lodge badly, or in case of continued dry weather, it may sometimes be necessary to cut it for hay when in the milk or dough stage rather than let it mature, in order to give the clover a fair chance.

USE BARNYARD MANURE TO HELP GROW CLOVER

When clover is grown in rotation with other crops and manure is used, the clover gets phosphorus and potassium, and even some lime from the manure. However, when only a moderate amount of manure is available and this is generally applied on the corn land three or four years before the clover is seeded, there is usually an insufficient supply of available lime and phosphorus and sometimes of potassium in the soil to produce the best results.

Fields which have been heavily manured for tobacco, cabbage, and other truck crops, rarely fail to grow splendid crops of clover, while fields on farms where little manure is produced or used, generally produce poor yields of clover. Farmers who have a fair supply of manure can greatly increase their yields of clover by supplementing this manure with lime and phosphate fertilizers. The farmer who grows clover successfully puts his soil in shape to grow larger crops of corn and small grain, and the increased crop will feed more livestock which will furnish more manure, and more manure will again help to grow better clover. The fertility of a soil which produces good clover can be easily maintained.

SUPPLY MEDIUM RED CLOVER WITH PLENTY OF LIME

Clover is a strong feeder on lime and must have a fair supply available in order to make its best growth. A two-ton crop of medium red clover will extract 150 pounds of lime, and four tons of alfalfa will take 400 pounds from the soil, while a two-ton crop of timothy requires only 40 pounds. It is thus very easy to understand why timothy will grow on soils which refuse to grow medium red clover or alfalfa. The lack of lime in soils is one of the big factors in causing Wisconsin farmers to grow six acres of timothy to each acre of medium red clover and twelve acres of a

mixture of timothy and clover (many times mostly timothy) to each acre of medium red clover.

The clover crop can not gather free nitrogen from the air unless the clover bacteria find conditions favorable for their development. It is known that these bacteria do not thrive in a soil which is low in available lime. Lime must therefore be supplied to the soil when needed to insure good inoculation and nodule development on the roots of clover. If clover does not have nodules on its roots it has no nitrogen-gathering power, but must extract all its plant food from the soils, as do corn, the grains, and other non-leguminous crops. Whenever the difficulty in getting a good stand of clover is not due to the bad effect of the nurse crop and when the soil is in a sufficiently high state of fertility to produce fair yields of corn and oats, and not of clover, the need of lime is the most common cause of the difficulty. The amounts of lime to use and methods of application are discussed on pages 20 and 21.

Supply Medium Red Clover With an Abundance of Available Phosphorus

That clover requires considerable available phosphorus is a very important fact to recognize. There is a third more of the element phosphorus in a ton of clover hay than will be found in a ton of timothy hay. Unless there is enough of this element in available form, left after the growth of the grain preceding the clover, the clover is unable to make good growth. Almost without exception soils that are deficient in lime are also deficient in phosphorus; so that the use of some form of phosphorus in addition to lime is necessary in order to get a good stand of clover. The lime should ordinarily be applied to the corn and the phosphate for the grain crop with which the clover is sown. For amounts and methods of applying phosphates see pages 14 and 15.

The experience of the Illinois Experiment Station illustrates the importance of phosphorus in addition to lime for clover and alfalfa. On land which had received manure only in rotation, the yield of clover was 2.53 tons an acre. Lime in addition raised the yield to 2.94, while phosphorus and lime together produced a yield of 4.17 tons an acre. In the case of alfalfa the yield on land which had been manured only was 1.96 tons as an average

for the years 1915 and 1916. Lime in addition to manure made the average 2.9 tons, while the addition of phosphorus as well as lime raised the yield to 4.4 tons. These results could be duplicated on much of our Wisconsin land, especially the dark prairie loam soils.

PHOSPHORUS

The element phosphorus exists in all soils in very small amounts. Many of the best types of soils in Wisconsin contain only 1,200 pounds of phosphorus in an acre of soil to a depth of eight inches, and this is in a form which becomes available to crops very slowly. It is constantly being lost from the farm in

FIG. 2.—DOUBLING THE YIELD BY USE OF RIGHT FERTILIZERS

When 500 lbs. of 16 per cent acid phosphate per acre were applied to land which had received both manure and limestone the yield of alfalfa was nearly doubled.

crops, milk, and in the bones of animals sold. It can not be secured from the air and the loss from the soil must in the long run be made good through the addition of phosphorus fertilizers in some form. It is well understood that when grain, hay, potatoes, or other cash crops are sold, this element is removed from the farm.

If considerable amounts of bran or cottonseed meal are fed, which are relatively high in phosphorus, the supply of this element may be maintained. It would usually be necessary to feed

at least one-half ton of bran or cottonseed meal to each cow on a dairy farm per year to maintain the phosphorus supply of the soil. Since comparatively few farmers do that, some phosphate fertilizer should be used.

PHOSPHATE FERTILIZERS PAY

In addition to the long time experiments being conducted on the substations, a number of field trials on the benefit of phosphate fertilizers have been made. In these experiments acid phosphate at the rate of 300 pounds to the acre, costing about $3, has been applied broadcast on farms on which dairy stock is maintained and all stable manure available is used in rotation.

Table I shows the results of phosphate treatment on eight representative fields of oats grown on land which was in corn the year preceding and received manure for the corn.

TABLE I—ACRE YIELDS OF OATS WITH AND WITHOUT PHOSPHATE FERTILIZERS

Farmer	Soil Type	Phosphate	No Phosphate
		Bushels	Bushels
Mitchell	Silt loam	87	69.5
Haswell	Silt loam	94.3	64.6
Brown	Sandy loam	44.0	38.0
Lee	Silt loam	48.9	45.9
Vernon County Farm	Silt loam	50.3	46.8
Lyon	Silt loam	69.9	50.0
Sudgen	Sandy loam	22.5	17.5
Craig	Sandy loam	41.6	26.7
Averages		57.3	44.8

The average of these eight cases shows an increase of 12.5 bushels of oats which at 40 cents a bushel would be worth $5. At least one-half the value of the phosphate applied is still in the soil for the benefit of clover or other crops following. Charging $1.50 against the oats would leave a profit of $3.50 per acre. There would be an equal profit from the other half on the clover next year.

A number of trials on the application of acid phosphate to corn have also been made from which representative cases are shown in Table II.

TABLE II—EFFECT OF PHOSPHATE FERTILIZERS ON WISCONSIN CORN.

Farmer	Kind of Soil	Manure in Rotation Plus Phosphate	Manure in Rotation No Phosphate
		Bushels	Bushels
Griffin	Sandy loam	30	20
Ashland Experiment Farm	Red clay	36.8	30.4
Brown	Sandy loam	84.3	71.1
Wickstrom	Silt loam	74.6	70.5
Irish	Silt loam	67.9	63.7
Sudgen	Sandy loam	67.5	54.8
Craig	Sandy loam	60.2	37.6
Hopkins	Silt loam	46.6	44.6
Bruins	Silt loam	79.6	75.4
McCutchin	Silt loam	80.0	79.1
Brueckner	Silt loam	90.2	86.3
Average		65.3	57.6
		Corn Silage	Corn Silage
		Tons	Tons
Murrish	Silt loam	15.8	8.7
Marshall	Silt loam	7.8	6.7
Spalbeck	Silt loam	14.1	11.7
Average		12.6	9.0

The average of these 11 trials shows an increase of 7.7 bushels per acre, which at 45 cents per bushel would be worth $3.50. In this case also not more than one-half the cost of the fertilizer should be charged to the corn, leaving a profit of $2 an acre.

A large number of determinations of the increase resulting from the use of phosphate fertilizers in addition to stable manure have been made in adjoining states.

At the Ohio Experiment Station the addition of 320 pounds of acid phosphate to manure and lime every three years has given an average annual increase above that receiving manure and lime only, for twenty-one years, of 8⅔ bushels of corn, 5½ bushels of wheat, and 838 pounds of clover. This increase is worth over $20, while the phosphate cost $4. The director of the Ohio Experiment Station says:

"Acid phosphate, either with or without manure, has given large profits in all cases. Per dollar invested, it has been by far the most profitable of all the fertilizer treatments, either alone, with lime, or with both lime and manure."

In Indiana the experiment station makes the following statement:

"As a general average of 95 crops of corn, wheat, and clover on five experiment fields during the last 12 years, acid phosphate

has yielded crop increases valued at $8.46 an acre a year, at an average cost of $1.38."

Governor Hoard was a pioneer in the use of phosphate fertilizers on the dairy farm. This practice made it possible to grow the splendid crop of alfalfa shown in the picture on the cover of the bulletin which is from a recent photograph of the Hoard homestead.

Forms of Phosphate Fertilizers

The chief forms of phosphate fertilizers available to Wisconsin farmers are acid phosphate, treble superphosphate, raw rock phosphate, and bone meal.

Bone meal is an excellent form of phosphate fertilizer, but the supply is very limited. It is obtained from the packing houses and other slaughter houses. It is more available to crops than rock phosphate, but not as quickly available as acid phosphate.

Raw rock phosphate is found in natural deposits in South Carolina, Tennessee, Florida, Idaho, Utah, and Montana. It is prepared for use as a fertilizer by being reduced to fine dust which will pass through a screen having 100 openings to the linear inch. It is a relatively insoluble material and the fine grinding makes it become available more rapidly for the use of plants. When this fertilizer is used in connection with considerable organic matter such as stable manure or on a green manuring crop being plowed under it gives excellent results when the soil is deficient in phosphorus.

Acid phosphate is the form of phosphate fertilizer most extensively used. It is made by treating one ton of raw rock phosphate with one ton of strong sulphuric acid, which has the effect of converting the phosphorus into a much more available and active condition. It usually contains either 14 or 16 per cent of soluble phosphoric acid. More highly concentrated forms are also made.

Treble superphosphate is a comparatively new form of phosphate fertilizer. It is similar to the ordinary acid phosphate except that it carries approximately three times as much phosphorus.* This material has not been used in the field very long, but the trials so far indicate that it will give results equal to those produced by acid phosphate. Under present conditions in

*This means that one ton of treble superphosphate is practically equal in value to three tons of 16 per cent acid phosphate. The statement on page 37 of Wis. Agr. Ext. Cir. 142, **"A Decade of County Agent Work"** in regard to this comparison is not clear.

Wisconsin, acid phosphate and treble superphosphate are probably the two best forms to use.

PHOSPHATE FERTILIZERS NOT LOST BY LEACHING

There is practically no loss of phosphorus from the soil by leaching; so that once a phosphate fertilizer has been worked into the soil it will remain there until the growing crops exhaust it. It is best, therefore, to put on as much phosphate fertilizer at one time as will be needed in the crop rotation, whether that be three, four, or five years in length; and it makes relatively little difference whether the phosphate is applied to the land the year corn is to be planted, or whether it is put on when oats are being sown. All crops need this element and the benefit from its use is as great in the case of oats as of corn, and its effect on clover or alfalfa is even greater than on corn or oats.

FIG. 3.—CORN IMPROVED BY 16 PER CENT ACID PHOSPHATE

The application of 400 lbs. of 16 per cent acid phosphate per acre improved the quality of corn grown on black prairie soil. The ears of corn were filled out much better, which increased the percentage of shelled corn to cob. The corn also matured one week earlier.

AMOUNTS OF PHOSPHATE FERTILIZERS TO APPLY

When raw rock phosphate, the insoluble slow-acting form is applied, the applications are generally from 1000 to 2000 pounds an acre. The slow availability is being made up for in quantity. This material must always be applied along with barnyard manure, green manuring crops, or crop residues. When it is applied

to soils that are deficient in organic matter the rate of application should be larger.

On good upland soil where dairying or general farming is practiced, the use of 300 pounds of 16 per cent acid phosphate or 100 pounds of treble superphosphate to the acre every four years will maintain the phosphate supply. If much grain, potatoes, or other crops are sold, about double these amounts should be used.

On soils relatively low in fertility somewhat more phosphate should be used at first. This is especially true of dark prairie soils which have grown corn or small grains a long time without the use of manure or other fertilizer. On peat or muck soils, larger amounts of phosphate fertilizers are needed, since these soils have a relatively small amount of this element. While the peat and muck soils of the southern and eastern portions of the state in the limestone region usually do not need phosphate the first few years after they are brought under cultivation, it is practically certain that they will need this element after a number of years of cropping. All of the peat and muck soils in the central and northern part of the state require phosphate from the beginning.

BROADCAST OR HILL APPLICATIONS OF PHOSPHATE FERTILIZERS

Any farmer who plans to improve or even maintain the fertility of the soils on his farm will want to fertilize all the crops in the rotation. A small amount of phosphate fertilizer applied with a fertilizer attachment on a corn planter will drop it near the hill and in this way the corn will receive marked benefit, but there is little benefit obtained by the oats or clover following the corn in this method of application. On the other hand, if the phosphate is distributed broadcast in larger quantities and worked into the soil for either corn or oats, the crops following will receive their portion of the benefit. Unquestionably the best practice for the dairy farmer to follow is the broadcast application, though it makes relatively little difference whether the phosphate be applied directly to the corn, oats or other grains.

Acid Phosphate does not make soils acid. It might be supposed that acid phosphate would have a tendency to make the soil acid. But such is not the case. The acidity of the fertilizer is of a kind which entirely disappears, and experience has shown

that its use for a long period of years does not make the soil more acid than it would be without it.

METHOD OF APPLYING PHOSPHATE OR OTHER FERTILIZER

Acid or treble superphosphate, as well as other commercial fertilizers, are salts and will injure the seed and prevent germination if they are in immediate contact with them. When the fertilizer is applied in the hill as it sometimes is with corn and other hill crops, there should be at least one-half inch of soil between the seed and fertilizer. Drills which sow both grain and fertilizer are made so that the grain and fertilizer are not too closely mixed.

The condition of the soil should also be considered in using fertilizers. When the soil is quite dry, fertilizer is more apt to injure the seed than when moist. Three hundred pounds of fertilizer to the acre, applied with a grain drill, will not injure the seed even when quite dry, but much larger amounts may. On very sandy soils there is more danger of the fertilizer injuring the seed than on heavier soils because they hold less water in which the fertilizer will dissolve. When applied in the hill for corn, 100 to 125 pounds an acre is all that can safely be used under ordinary conditions. When drilled in for corn, 175 to 200 pounds may be used.

FERTILIZER AND LIME DISTRIBUTORS

Phosphate or other fertilizers or lime should be uniformly distributed, so that some will be near every plant. Ground limestone is applied at the rate of from 2,000 to 4,000 pounds or more an acre, while with phosphates and other fertilizers the amount applied for staple crops is usually from 200 to 400 pounds. It is, therefore, very difficult to construct a machine which will satisfactorily distribute both fertilizer and limestone, although excellent machines are on the market for distributing each separately. The fertilizer distributor may be a part of a grain drill or a separate machine. The machine for distributing ground limestone should be provided with a double agitator so as to secure continuous feeding.

End gate seeders which will distribute proper amounts of either fertilizer or ground limestone fairly well are available.

When a fertilizer distributor is not available the acid phosphate or other fertilizer may be spread evenly over the manure

in the manure spreader, and so receive a very fair distribution. This method will give very good results until such time as a grain drill with fertilizer attachment can be purchased. The amount to be applied on each spreader load must be calculated so the right amount per acre will be applied. An old drill or seeder may be used to distribute the phosphate, going ahead of the grain drill.

POTASSIUM

Upland Earthy Soils

Potassium exists in all upland earthy soils in large amounts, but in relatively unavailable form. Chemical analyses of these soils show that they often contain from 35,000 to 40,000 pounds an acre eight inches, while these same soils will contain only one-eighteenth as much phosphorus. On most soils of fairly heavy texture, when live stock is maintained, and the manure carefully used so there is considerable actively decomposing organic matter in the soil, a sufficient amount of potassium will become available from year to year to supply the needs of general farm crops. There are some crops that need relatively large amounts of potassium such as potatoes, tobacco, and cabbage, and they will often be benefited by some addition of potash in fertilizer form.

Peat and Muck Soils

Peat and muck soils are very different from the upland earthy soils. They are generally very low in potassium and it must be applied in some form unless considerable stable manure is available. When these soils are virgin they may raise from two to four crops without the addition of potassium fertilizers, but after this they must be used regularly. The equivalent of 100 pounds of high-grade muriate of potash to the acre every other year will be necessary in the case of small grain or hay. Double this amount will be needed for corn and for truck crops such as cabbage, sugar beets, or onions which make a heavy growth and drain heavily on this element of plant food, unless manure is used. When the farm includes upland as well as marsh the manure should largely be used on the upland and potash and phosphate when needed should be used on the marsh.

SANDY SOILS

Sandy soils lie between the heavier earthy soils such as silt or clay loams and the mucks in regard to their potassium requirements. The use of some potassium on these soils will often be profitable, especially when crops are grown that use rather large amounts of this element.

MIXED FERTILIZERS

Since certain crops such as cotton, tobacco, potatoes, and vegetables are grown in many parts of the country by farmers who do not keep much livestock and who do not rotate these crops with legumes, fertilizers containing nitrogen and potash, as well as phosphorus must be used. Mixed fertilizers containing varying amounts of nitrogen, phosphorus, and potash are therefore manufactured and offered for sale. The composition of these fertilizers is indicated by a formula. A 2-10-4 fertilizer, for instance, is one containing 2 per cent of ammonia, or nearly 2 per cent of nitrogen, 10 per cent of phosphoric acid, and 4 per cent of potash. A 6-12-0 contains 6 per cent of ammonia containing about 5 per cent of nitrogen, 12 per cent of phosphoric acid, and no potash.

One of the chief sources of nitrogen is nitrate of soda; of phosphoric acid, acid phosphate, and of potash, muriate of potash. Nitrate of soda contains about 16 per cent of nitrogen, acid phosphate about 16 per cent of phosphoric acid, and muriate of potash about 50 per cent of potash; so that 100 pounds of a 2-10-4 fertilizer would contain about the equivalent of 12½ pounds of nitrate of soda, 62½ pounds of acid phosphate, 8 pounds of high-grade muriate of potash, and 17 pounds of filler. These mixed fertilizers cost $5 to $10 a ton more than the plant food in them would cost if bought in the separate forms indicated above. This difference represents the cost of mixing, and profits. Mixed fertilizers should contain not less than a total of 16 per cent of plant food elements.

When nitrogen and potash are to be used as well as phosphoric acid, there is some advantage in using these mixed fertilizers. The filler gives it a good mechanical condition so that it will distribute easily and remain in condition to be used longer than is the case with the substances containing the elements separately.

But when the farmer needs to use only a phosphate fertilizer, purchasing a mixed fertilizer means that he is buying not only nitrogen and potash which he does not need, but he is compelled to pay a considerably higher price for the phosphate he gets than is the case when he buys a fertilizer containing phosphate only. While it is quite true that these mixed fertilizers have a very important place in the production of many special crops, their use is not necessary in dairy or stock farming as a rule, and phosphate fertilizers in addition to lime are usually the most profitable.

In the case of sandy soils on which an effort is being made to raise their state of fertility, it may be desirable to use moderate amounts of mixed fertilizer containing both nitrogen and potash as well as phosphorus such as a 4-10-4 fertilizer until clover or other legumes are produced or manure is available. On many muck soils it is necessary to use both potash and phosphorus and here a 0-10-10 fertilizer can be used to advantage. This is true generally of muck or peat soils in the central and northern part of the state. Or the farmer can buy the separate potash and acid phosphate fertilizers and mix them as they are to be used, thus saving the extra cost of the mixed fertilizers.

LIME

Calcium, the chief element in limestone, and magnesium are two other closely related elements which all plants require for growth. Plants vary greatly in the amount of calcium or lime in the soil necessary for their growth. Alfalfa requires a large amount of this element and in available form. Medium red clover, barley, sugar beets, and tobacco are other plants requiring fairly large amounts while such crops as corn, oats, soy beans, timothy, and rye will grow with smaller amounts of available lime, or are able to get their supply from forms which are not readily available to the other plants mentioned.

Lime can exist in the soil in different combinations with other substances. Ground limestone or air-slaked lime is lime carbonate. This is somewhat soluble in soil moisture and the lime it contains combines readily with the nitrogen which is being nitrified and is absorbed by plants.

But lime in other forms than carbonates can also be used—though not so readily. These other forms of lime exist in acid

as well as non-acid soils. So all crops can get some lime from acid soils and some crops can get enough for very fair yields. But lime in the form of carbonate or oxide will usually produce a profitable increase of most crops on acid soil after they have been farmed 10 to 15 years and sooner on sandy soils.

On the very acid soils at Marshfield the addition of two tons of lime per acre to manure and phosphorus increased the yield of corn from 56.5 bushels to 63.95; of oats from 57.2 to 63.4; and of clover from 4527 pounds to 5020 pounds an acre. The figures for corn and clover are the average for four years and for oats for five years. This increase of 7.4 bushels of corn, 6.2 bushels of oats, and nearly one quarter of a ton of clover, would have a value of about $9 for the three years of a rotation following the application of lime. This land had been farmed about 12 years before the experiments were started.

Even on very poor soil, proper use of lime and fertilizer will permit a good crop of clover when the rainfall is at all satisfactory. At Sparta on very poor sandy soil exhausted by a number of years of cropping, the use of phosphate, potash, and lime gave a yield of clover in 1914 of 3800 pounds an acre in two cuttings, while without fertilizer there was no catch of clover whatever. With lime alone the yield was only 600 pounds an acre.

FORM OF LIME TO USE

Lime is most generally used in either of two forms: first, quick or burned lime after it is water slaked; and, second, ground limestone. Quick lime is relatively expensive, and it is so unpleasant to slake and spread that comparatively little lime is used in this form in the West, though it has been used largely in that form in eastern states for a great many years. While it is necessary to use practically twice as much ground limestone as quick lime, its convenience in handling is much greater.

RATE OF APPLICATION OF GROUND LIMESTONE

When the soil has been farmed 15 years or more and is quite acid and alfalfa is to be grown, from two to three tons of a good grade of ground limestone must be used. For other crops, two tons will usually be sufficient for the first application and an average of one ton an acre every four to five years thereafter will maintain the supply of this element.

It is not necessary to add as much limestone as would be needed to entirely correct the acidity. This would often require four to six tons or more to the acre, while the results reported by F. L. Musbach at Marshfield show excellent results from two tons an acre, and the studies of E. B. Fred and E. J. Graul show that nearly as much benefit is secured by the use of one-half the amounts of lime necessary to neutralize the acidity as by the whole amount.

The chief loss of lime from the soil is not that which the plants take, but by leaching downward. The average losses from limed fields by leaching is equal to from 400 to 600 pounds of limestone a year, while the crops would take only 25 to 150 pounds a year. Smaller applications made more frequently would require less limestone, but would involve more labor.

When to Apply Limestone

The lime or limestone on the dairy or general farm may be applied either on land on which corn is being planted or for oats or other grain with which clover is being seeded. It is important that the lime be thoroughly mixed with the soil, and so it is best to apply it after plowing; so that any further working of the ground in fitting it for a crop will mix it more thoroughly with the soil.

The most marked influence of lime is on the clover, but somewhat better results with it are secured when the lime is applied a year before the time of seeding to clover. Still, this difference is not sufficient to cause farmers to hesitate to apply the lime with the grain crop when clover is being seeded, if that is more convenient.

So far as possible the lime should be applied in the fall after plowing, since the roads are usually better for hauling then, and time is not so pressing as in the spring when the grain is being seeded. If two or three farmers co-operate in the purchase and use of a lime distributor, they can also work to advantage in hauling the ground limestone from the car or quarry. By using one extra wagon and having sufficient teams to keep the distributing going, there will be no extra shoveling of the limestone. If this is not practicable it may be necessary to store the limestone in a shed, and haul it to the field when needed. If a lime distributor is to be used it is important that the ground limestone be dry or it will not run freely from the machine.

THE MANURE SPREADER MAY BE USED

By putting a thin layer of manure or straw in the spreader, the limestone can be placed on it and spread at the right rate.

Often the limestone can be hauled during the fall or winter to the field and put in piles so that it can be reached with the spreader easily when the ground is being fitted for seeding or planting in the spring.

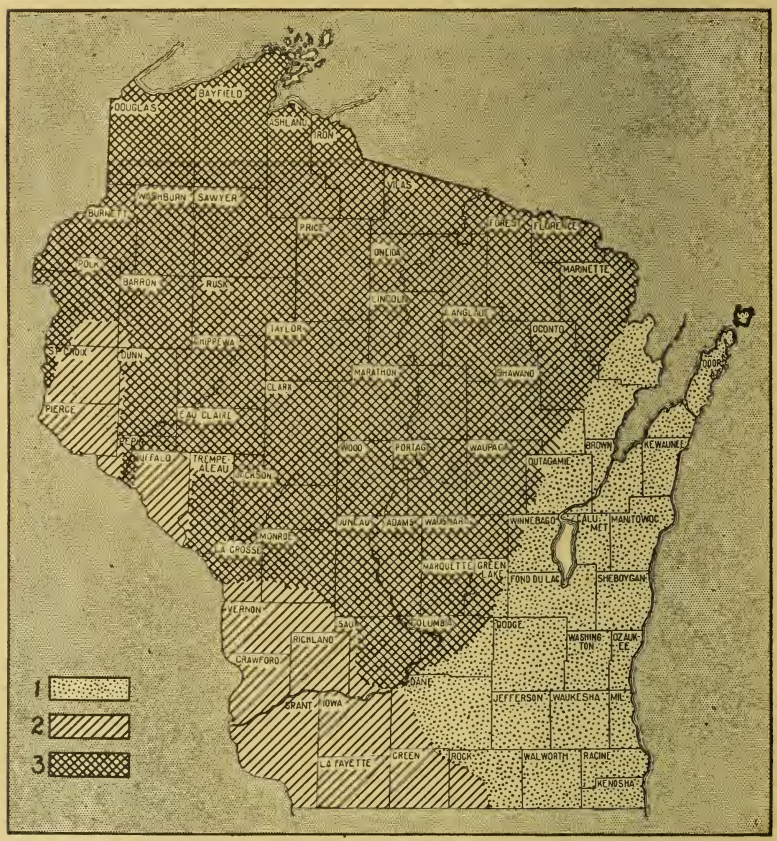

FIG. 4.—TYPES OF WISCONSIN SOILS

1—Glaciated limestone country with only occasional fields needing lime.

2—Limestone country not glaciated. All but lowest slopes need lime for clover and alfalfa.

3—Country with little or no lime carbonates in the soil. This land usually needs lime after it has been farmed ten to fifteen years.

Distribution of Lime In Wisconsin

The eastern, southern, and portions of the western part of the state are underlaid by limestone. The ice during the Glacial Period swept over the eastern part of the state, ground off much of the limestone and mixed it with the soil; so that the need for lime in this part of the state is limited to a small part of the area. It is usually needed on dark colored upland soils from which the organic matter has caused it to be leached. Light colored upland soils need lime only in patches, usually on the hilltops. The marsh soils in this region have lime washed down from the surrounding upland.

In the other parts of the state which have limestone rock, but were not glaciated, the lime in carbonate form has largely been leached from the surface soil except near the base of limestone hills; and the use of lime is proving very generally beneficial in these parts of the state.

In the other sections of the state where there is no limestone the soils are more or less acid and will be benefited by liming after several years of cropping.*

Care of Manure

The care and use of the manure produced is the most important thing in the management of dairy and stock farms. The chief advantage of these types of farming is that the proper use of the manure or other waste products makes it possible to maintain productive yields with comparatively little purchased fertilizer. But it is only when intelligent care is taken that this result is possible. Much of the available plant food in manure is readily soluble in water; so that if the manure is exposed to the rain in flat or shallow piles, a considerable part of its value is lost. This affects nitrogen and potash especially. It is important also to recognize that a large portion of these element is in the liquid part of the manure and that it is necessary, therefore, to use bedding or absorbents freely to prevent a considerable loss. This is particularly true of potash, about 60 per cent of which is contained in the liquid manure.

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*For further information about liming See Wis. Agr. Exp. Sta. Bul. 230 *Soil Acidity and Liming.*

If this potash is largely conserved and returned to the soil, it will form a revolving fund to which there are sufficient additions from the soil itself constantly being made to replace unavoidable losses; but if a large part of the potash in the feeds consumed is lost by leaching of the manure, then the soil is not able to supply this element with sufficient rapidity to permit the best growth of crops so that fertilizers containing potash would have to be used.

The use of sufficient absorbents such as oat straw, shredded cornstalks, or even dried peat, is of the utmost importance. Ordinarily the best practice is to haul the manure directly to the field. When this is not practicable the pile should be kept compact, well trodden, and moist as it can be, through the use of a slightly saucer-shaped manure pit, from the outer sides of which the ground slopes away readily; so as to prevent water washing into the pit itself. In this climate the use of shelter is of doubtful importance, though where more rains occur, particularly in the winter, a shed roof is very helpful.

The rate and frequency with which manure is applied depends in part on the character of the soil on the farm. On lighter soils more frequent applications of smaller amounts are desirable than on heavier soils. Five or six loads per acre every third year is desirable on the sandy loams, while eight to twelve or more every fourth or even fifth year may be used to advantage on heavier soils.

HUMUS

The importance of as large a supply as possible of actively decomposing vegetable matter in the soil must not be overlooked. It is through the decomposition of this vegetable matter that chemical reactions are produced which aid in making much of the plant food in the soil available to crops. Also, this organic matter has an important influence in increasing the water holding capacity of the soil, and in the case of heavy soils in improving their tilth or working qualities. All straw and other roughage produced should be worked in with the manure and returned to the soil, and whenever possible the green manuring crops should be grown and plowed under.

lletin 342 April, 1922

W75b

Milk — the Best Food

AGRICULTURAL EXPERIMENT STATION
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MADISON

DIGEST

For the young, milk is a perfect food. For the adult it is valuable as a supplement to the ordinary diet. By its liberal use the diet is made complete so that the greatest efficiency and well being of the individual result. Page 1.

Milk is not a beverage like tea or coffee; it carries important food constituents. In energy content alone a quart of milk is approximately equal to a pound of lean steak or eight eggs. Page 5.

Milk contains superior proteins in contrast to wheat, corn, rice and potatoes. Whether it is used in the form of whole milk, skimmed milk, buttermilk, or even whey, or as the important product cheese, milk furnishes a protein which seems to be just what the body needs. Page 7.

Milk makes good the mineral deficiencies in the diet. Grains and potatoes are notoriously poor in their content of chlorine, calcium, and sodium but milk makes up this deficiency in an excellent manner. Page 8.

Milk also contains vitamine B and vitamine C in addition to vitamine A. These vitamines are both indispensable to life. Page 13.

The use of "filled milk" for infant feeding is intolerable and should be prohibited by law. Whole milk contains vitamine A in large amounts while "filled milk" does not. Without vitamine A an animal cannot live; lack of it results in early cessation of growth, inflamed eyes, pneumonia, and then death. Page 18.

Vitamines A and B are not easily destroyed by heat. Milk, therefore, can be pasteurized, sterilized, and dried without affecting them. Page 18.

It is not safe to use any processed milk for infant feeding for long periods of time without supplementing it with an efficient anti-scorbutic such as orange juice or tomato juice. This is necessary because vitamine C is easily affected by heat treatment. Page 19.

Whole milk is a great factor of safety in the diet. It should therefore be used liberally both as an article of food by itself and in cookery. Page 19.

Milk the Best Food

By H. Steenbock and E. B. Hart

For countless ages the varied races of the world, doing many kinds of work and living in different climates, have been unconsciously taking part in a huge food experiment, the results of which show man what to eat and what not to eat. Some peoples have lived exclusively on plant materials—seeds, roots, leaves, and stems; others have added thereto meat, fish or eggs; some have used milk from the cow, goat, mare and buffalo; and still others have lived on meat with small additions of plant material.

Results show that the more virile peoples which today are the leaders in the onward march of civilization, have made use of the animal as a provider of food, particularly of milk and dairy products.

Milk a Perfect Food

For the young, milk is a perfect food. It, like the egg, is a product of nature which sustains and allows development of the helpless young. In it are concentrated many valuable substances found sparingly in plants which often are temporary contributions from the tissue of the mother herself when her diet is not complete. Milk represents the final result of ages of experimentation where the failures have been buried with the past.

For the adult, milk alone is not a satisfactory food. It is too dilute to be satisfying or convenient; it is too low in iron to prevent anemia; and finally it is not bulky enough for proper elimination of the waste products from its digestion. Milk is valuable for the adult as a supplement to the ordinary diet, however. By its liberal use the diet is made complete so that the greatest efficiency and well being of the individual result.

Things Necessary in the Diet

At least five desirable requirements of a food are known at present. These are: Plenty of energy, an adequate supply of good proteins, suitable mineral matter, a sufficiency of at least

three kinds of vitamines, and for all but the infant a certain amount of roughage or indigestible material. Wheat, which for ages has been a recognized standard for human food, is lacking in two of these elements and contains little or none of two of the known essential vitamines. In fact, it is questionable if wheat as a food is superior to many of our other grains. Milk, on the other hand, carries most of these desirable qualities in a combination unequaled by any other food.

IMPORTANCE OF ENERGY

The energy content of food or that which keeps up our body temperature when we are cold and gives us the power to do work, much as fuel serves the engine, has often been the yardstick for measuring food values. "How many calories of other foods can be purchased for ten cents?" has been the slogan of food advertisers in boosting their products. Food energy is important for we are measured by the energy we can put into our mental or physical work, and without a sufficient supply in our diet under heavy strain, we tear down body tissues to supply the demand.

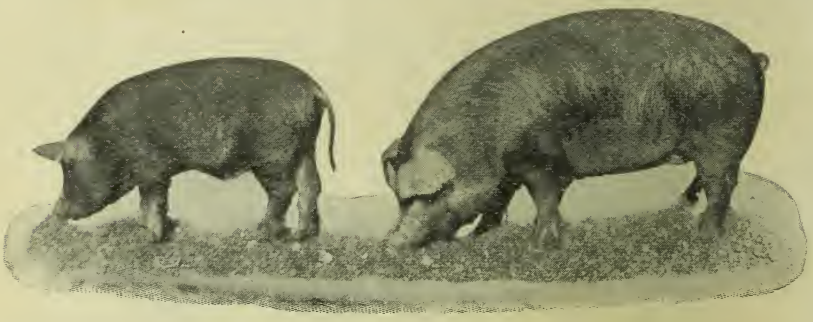

FIG. 1.—PLENTY OF ENERGY ALONE IS NOT SUFFICIENT.

Both pigs received plenty of calories. The one on the left, weighing 55 pounds, had wheat meal and wheat gluten as its source of protein. The one on the right, weighing 165 pounds, received wheat meal and skimmed milk in approximately the proportions 1-1. They were started on their rations at the same time.

The body, however, is not an efficient transformer of this energy unless it is kept in good repair by other constituents of the diet and to this the calorie method pays no attention.

Of its ability to promote growth in the young the energy content of a food gives no indication except that with a deficient intake of energy, no matter with what food, gross deficiency in intake of most other constituents is bound to be the case. The

cheapest and most commonly used sources of energy for human food such as wheat, corn, rice, oats, and potatoes, which for economical reasons can and should make up 50 to 60 per cent of the food we eat, when used by themselves allow little or no growth to take place. This is illustrated in Fig. 1 where one of the young pigs was given a grain ration carrying plenty of energy in digestible form. Because it did not contain enough of other essential food substances, growth was much interfered with, but when these are supplied as with milk the other energy foods are excellent. Ordinarily the green parts of plants supplement other foods though rather imperfectly, so that satisfactory, though not the most rapid growth is obtained.

Milk ordinarily is not looked upon as an important energy yielding food, but rather as a drink. A quart of milk, as a matter of fact, is approximately equal in energy value to a pound of lean steak or 8 eggs, so that its energy content is far from being insignificant.

Most of the energy in milk is in the milk fat which is easily digested and absorbed, but a large portion is also in the milk sugar. Experiments have shown that milk sugar is the only sugar which has a favorable influence on the digestive tract. When used in the diet in liberal amounts milk sugar stops the growth of bacteria that cause decay and thus prevents the poisoning of the system. This is very important in the diet of the infant and child—both very sensitive to injurious substances—but even in the adult it may mean preventing the headaches and mental sluggishness so often resulting from indigestion.

IMPORTANCE OF PROTEIN

Next to energy the second important factor in food value is protein. How often we see or hear the statement "It is high in protein, the great blood and muscle building food." To be sure without protein these tissues cannot be built, but we now know as a result of work in our experiment stations that proteins differ tremendously in the extent to which the animal can use them for these purposes. For instance, if two animals as near alike as possible in ancestry, age, size, and vigor, are given one hundred (100) pounds, respectively, of the protein of milk and the protein of ordinary grains, there will be retained sixty-five (65) pounds of the milk protein, but less than thirty (30) pounds

of the grain protein in spite of the fact that they are both well digested and absorbed. These proteins are so different in composition that they cannot be utilized equally well for building body tissues. This in itself would not be a serious matter if the animal could advantageously eat so much more of the cheaper grain protein, but its capacity to do this is so limited that growth

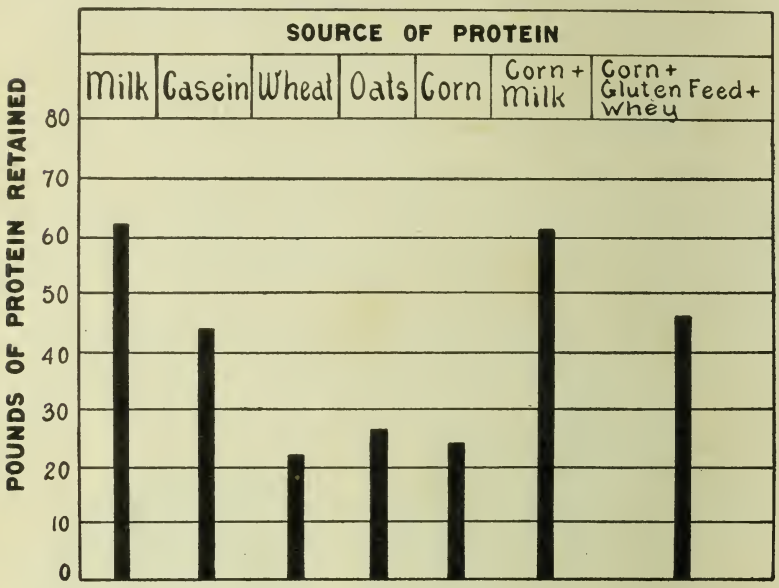

FIG. 2.—DIFFERENCES IN THE NUTRITIVE EFFICIENCY OF PROTEINS.

This chart shows the number of pounds of different kinds of protein which a pig can retain for growth from each 100 pounds of protein consumed.

and development suffer. Mixtures of grain proteins with milk proteins are as efficiently retained as milk protein itself since milk contains in highly concentrated form the essential substances. What grain protein lacks is supplied abundantly by the milk.

Even the small amount of protein in whey supplements grains excellently. In the Wisconsin experiments with growing pigs, where this by-product of the cheese industry was fed at the rate of four (4) pounds daily as a supplement to a corn meal gluten feed ration, 47 per cent of the total proteins fed were stored by the animals. Without the whey proteins, which were but 16 per cent of the entire protein mixture, only 30 per cent of storage

resulted. These figures are significant. Certainly our stockmen cannot afford to allow whey to be run into the gutter or creek to turn into a vile smelling waste product. It should be saved and fed to the stock.

Milk in any form, whether whole, skimmed, or as buttermilk or even whey, and as the important product cheese in all its dif-

FIG. 3.—HOW THE PROTEINS OF MILK INFLUENCE GROWTH.

Corn and clover or wheat and clover are not deficient in energy, minerals or vitamines, but the protein mixture is not as good as when milk is added. This picture illustrates what J. G. Halpin, of this station, has done with baby chicks of the same hatch. Those on the right received corn and fresh green clover; those on the left were given corn, clover and skimmilk. The average weight at the same age was respectively 84 grams and 260 grams.

ferent forms, is a superior source of protein. This it not because of the amount of protein—for the milk products listed differ too widely—but because the protein seems to be just what the body needs to build and repair its tissues.

What applies to milk protein in a large measure also applies to meat and egg proteins for they have helped enormously in the history of mankind in maintaining the human race under otherwise unfavorable conditions. But at present and, no doubt, as she will in the future, the dairy cow stands in a class by herself as an economical producer of excellent protein. This is true because she, of all animals, can use to best advantage the proteins of roughage such as hays, corn stover, and silage which are too bulky for human food.

IMPORTANCE OF MINERALS

When milk is added to a grain ration not all of its beneficial action is due to the betterment of the protein mixture. Part of it is due to the improvement of the mineral intake, especially that of sodium, chlorine, and calcium, in which grains are markedly deficient. As a matter of fact, on our grain rations it is this very lack of minerals, which especially build up the skeleton and

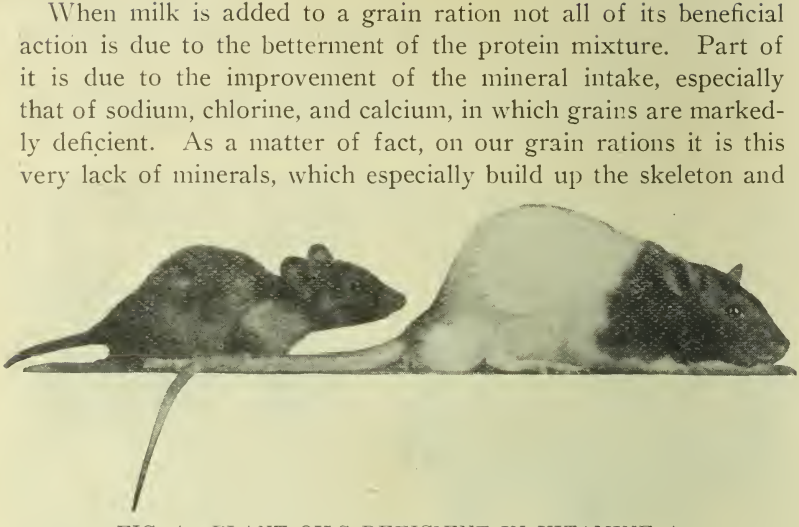

FIG. 4.—PLANT OILS DEFICIENT IN VITAMINE A.

The rat on the left received 5 per cent of cottonseed oil and the one on the right 1.5 per cent of butter fat instead of cottonseed oil; otherwise the rations were alike and the rats were of the same age. The plant oils lack vitamine A without which growth cannot proceed; yet this vitamine is contained abundantly in whole milk, eggs and the leafy portion of plants.

the blood, that becomes evident before the poor quality of the proteins. Unless minerals are present in sufficient amount, growth is impossible. So important is this adjustment that in different species of animals where the infant young normally grow at different rates, the rapidity of development follows in the same order as the percentage of mineral matter in the milks. Here again is an adjustment of nature to make milk a perfect food and fortunate indeed is man that in adult life he can avail himself of the milk of animals as a food, perhaps not exactly balanced to his needs, but more balanced than anything available in the plant kingdom.

VITAMINE A (FAT SOLUBLE VITAMINE)

In the last decade there has been forced upon the attention of the public the fact that energy, as fat and carbohydrate, good protein and mineral matter are not the only things required by an animal in its ration. If a mixture of these constituents is made from pure ingredients and fed to a *young* animal, it will

stop growing and die early from various complications. If fed to a *mature* animal sooner or later, depending upon the species and its nutritive condition, old age will set in prematurely, infections will occur and death will follow rapidly. This situation is caused by a lack of many substances collectively called vitamines, from vita, meaning life. Individually for want of a better system they are named in the order of their discovery after the letters of the alphabet.

FIG 5.—OLEOMARGARINE VS. BUTTER FAT AS A SOURCE OF VITAMINE A.

Two rats of the same age and same sex. The rat on the left received as its source of vitamine A 5 per cent of the ration from a so-called butter substitute, while the rat on the right received as the source of this vitamine 5 per cent of the ration as butter fat. Note the small size (109 grams) and the sore and infected eyes of the rat on the left as compared with the vigorous condition, bright eyes and larger size (262 grams) of the rat on the right.

Vitamines are not as yet known as pure chemical compounds which has often caused the skeptical to ask: "Well, how do you know that there are such things?" "Is it not something else that is responsible for the nutritive failure?" As a matter of fact, the reason that scientists are so certain of the existence of vitamines, is that lack of any one of them in the diet produces a perfectly definite reaction in the animal. Actually it is not necessary to go far to find parallel situations in other fields of science. For instance, no one will deny the fact that we do not as yet know what electricity is or what light is, and yet they are dealt with as separate phenomena to the great advancement of civilization. It is only a question of time before the nature of vitamines will be found out.

When Vitamine A is lacking in the diet of the young, growth ceases just as soon as the reserve supply of it stored in the body is exhausted. This may be a matter of months in the infant, but no exact data on this point are available. When growth ceases, or even before, the power to resist infections gives way, the eyes become red and swollen, filled with fluid, then with pus and finally the surface of the eyeball is left eroded and scarred, often inducing permanent blindness. In other cases the lungs become infected, causing a pneumonia which usually ends in death.

Vitamine A was first discovered in solution in fats, which caused it to be known as the fat soluble vitamine. Osborne and Mendel of the Connecticut Experiment Station, and McCollum, formerly of this Station, interested in a study of the things that an animal needs, found independently that butter contains something which lard and vegetable fats do not and that this substance was absolutely necessary for animal life. It was this discovery that caused so much attention to be given to the superior value of butter and its source, namely, milk. Now we know that there are other sources of this vitamine. It is found in the green parts of plants, in cabbage, in eggs, in beef fats, in ripe peas, in yellow corn, in yellow sweet potatoes, and in the highly pigmented carrot. But the fact remains that it is perfectly possible for man, through indifference in uncivilized regions, for economic causes and during starvation—as was so prevalent in many parts of the world in the last decade—to select a diet supposedly satisfactory, but very deficient in vitamine A. Here is where the value of milk and its products comes in. The cow and the goat, able to exist on grasses and hays, not directly consumable by man, concentrate this vitamine and put it out in their milk in a form available to man. Meat, on the other hand, is not so rich in it.

From the standpoint of dollars and cents as well as from the standpoint of maintenance of man's vigor and health, a word should be said in regard to the dairyman's competition with the oleomargarine manufacturer. Oleomargarine, as is well known, is produced from the hardened vegetable oils or the plant fats themselves mixed with a liquid oil obtained by pressure from lard, together with beef fats. This mixture in addition is often mixed with some butter and then churned with milk to give it a butter flavor.

Experiments have shown repeatedly that plant fats are totally

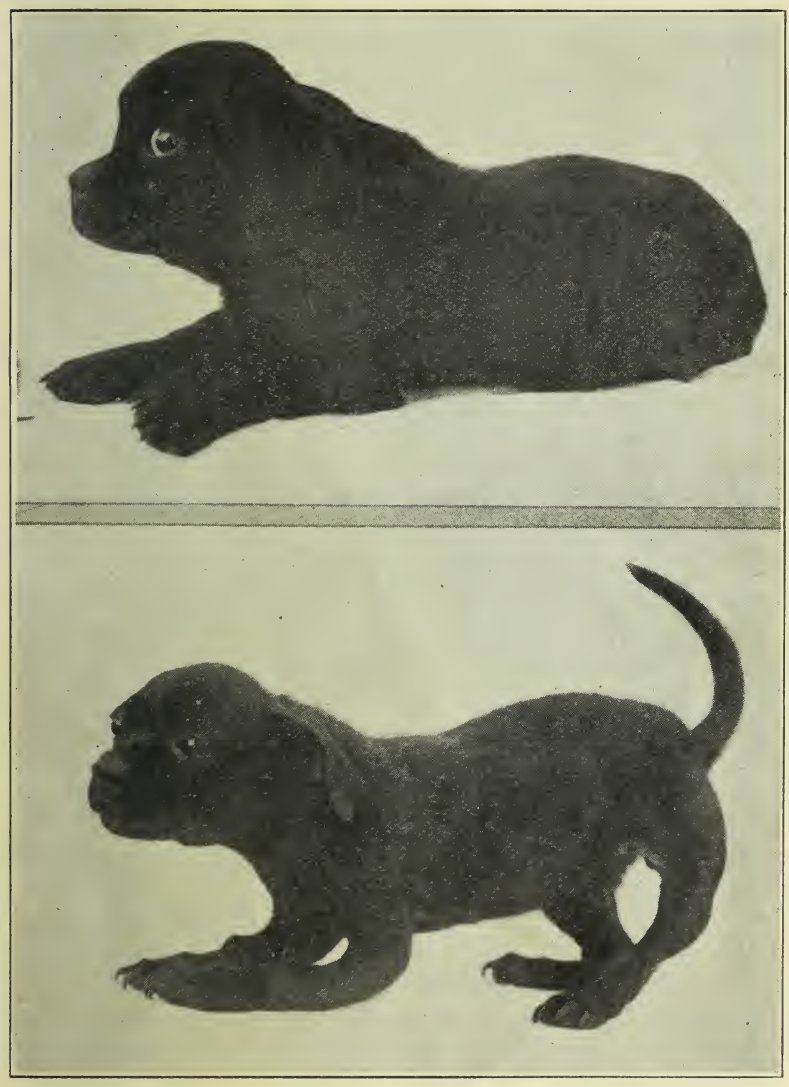

FIG. 6.—BUTTER FAT WILL PREVENT RICKETS.

Two dogs from the same litter brought up on cooked rolled oats, cooked corn meal, casein, salts and 7 ounces of skimmed milk daily. The upper dog received in addition ½ ounce of butter daily; the lower did not. The former was healthy and active in spite of the fact that originally it was an inferior dog and had lost one foot by accident. In 17 weeks it increased in weight from 870 to 4,290 grams. The lower dog was severely afflicted with rickets and died two weeks after the picture was taken. It originally was in excellent condition, but increased in weight only from 1,640 to 3,250 grams.

free from vitamine A, and that most body fats of animals contain but small amounts of it, although there are some exceptions. Fats in internal organs such as the kidney and liver are very potent as sources of this vitamine and occasionally the beef fats, especially the highly colored yellow ones, are as rich as butter.

FIG. 7.—SKIMMED MILK AFFECTS INFANT WELFARE.

This child of 14 months is again able to see with one eye after treatment with a diet of fresh milk, milk pudding and cod liver oil—all good sources of vitamine A. Previously it had received only centrifuged milk with rusks and other foods, all poor in vitamine A. This caused its eyes to be inflamed, resulting in permanent blindness of the left eye. (Taken from Journal of Hygiene relating the experience of Bloch in Denmark.)

As the fats from the internal organs are not used commercially and as beef fats make up only part of the final product, the result is that even the best of oleos are not to be compared with good butter. This criticism applies even more forcibly to the nut oleos which pride themselves on not being contaminated with animal

fats. The nut oleos are the greatest menace to the dairy industry because of their cheapness and the low price possible in the sale of the product. Furthermore, by their manufacture, the use of animal fats is decreased and the livestock industry loses the benefits which the oleo manufacturers claim to have given it by the extension of their activities. This latter is, however, a questionable matter.

Although fats other than butter are just as valuable sources of energy, it is a question whether or not the peoples of the world who have reached such a high degree of civilization subsisting on a dairy diet can adopt a radical change in their diet and decrease its vitamine content with safety.

With adults on restricted rations, observations have been made which suggest that cases of vitamine A deficiency, where the deficiency has attained a sufficient severity to cause eye symptoms, do occasionally occur. That such is the case with infants, where given little or no milk, there is no longer any question.

Mori, a Japanese physician, in 1904, a decade before anything was known of vitamine A, described over a thousand cases of eye disease among children, which he cured by giving them chicken livers, an organ now known to contain vitamine A. Later Bloch, a Danish physician, observed many cases of the same trouble among peasants, in rural districts near Copenhagen, where it became the practice to sell the butter fat produced on their farms, giving skimmilk instead of whole milk to the children. (See figure 7.) Here the disease when it had not progressed too far was promptly cured by replacing the whole milk in the diet or by giving cod liver oil. Both of these doctors knew nothing about vitamines and attributed the benefits to the fats themselves, but Monrad later pointed out that vitamines were probably concerned. Of this there now is no longer any question, for not only is the effect not produced by all fats, but those fats such as butter and cod liver oil which are active in high degree can be completely destroyed by making soaps of them without destroying the vitamine.

Vitamine B (Water Soluble Vitamine)

Years ago, when modern milling methods were first used in the orient, there became prevalent a disease known as beri-beri. Large numbers of people in Japan and the Philippines, in China, in India, and the Malay Archipelago came down with this malady.

It is characterized by extreme loss of weight, accompanied by a dropsical condition and some nervous disturbances. This epidemic which scientists could not account for was due to the fact that the people in their desire to use rice without the seed coats, used modern machines which removed not only the outer coats, but also the germ and with that most of vitamine B. With the crude native mills that had not been entirely possible. As the

FIG. 8.—EFFECT OF A DEFICIENCY OF VITAMINE B.
A pigeon showing a neck spasm in an acute attack of beri-beri resulting from the consumption of a ration of polished rice which is deficient in the vitamine B.

diet of these peoples is naturally very restricted, consisting mainly of rice supplemented with some fish, the amount of vitamine B in the ration had been reduced to the danger point. Such also was the case with the rations of the British colonial troops in the siege of Kut. Even in Labrador, beri-beri appeared among the fisher folk through their dieting too extensively on patented wheat flour, for from wheat flour, as from the ordinary polished rice on the market, most of vitamine B has been removed in the milling process.

Experiments with small animals such as the rat showed that those foods which caused beri-beri in the human also caused similar symptoms with them and did not allow growth to take place. In man with his relatively slow rate of development this effect on growth had not been so evident. Fortunately for animal life, vitamine B is not limited in occurrence.

It does not occur in fats, sugar or starch, but is found abun-

FIG. 9.—EFFECT OF MILK PRODUCED ON A RATION LOW IN VITAMINE B.

This rat received as a natural food only 10 per cent of the ration as barley grain. The rest of the ration consisted of purified materials. The supply of vitamine B was sufficient for her own maintenance, but not enough for both herself and an abundant supply in the milk. The young show the effect of this shortage. They grew rapidly for a time, but suddenly lost weight and showed periods of great excitabiliy. They had a rolling gait and often suffered from convulsions. This class of vitamines is present in sufficient amount in milk as normally produced from natural foods.

dantly in all our unmilled grains, in potatoes, milk, eggs, and to a lesser extent in meat and the green parts of plants.

Except in unusual circumstances, it is not especially imperative for man to look for an efficient carrier of vitamine B to supplement his diet. Milk is not especially high in vitamine B, as ounce for ounce it does not differ much from grains. In fact, when diluted with water 1 to 1, for infants' use in place of mother's milk, not enough of this vitamine will be furnished. This can be overcome by using water extract of grains in place of water.

Like vitamine A, vitamine B cannot be built by the animal, but ultimately must come from plant sources. When the diet of the nursing mother is deficient in it, her milk will be abnormally low in vitamine. The effect of this becomes evident as symptoms of beri-beri are produced in the young. (See figure 9.)

VITAMINE C (ANTI-SCORBUTIC VITAMINE)

Dating primarily from the time when man went on long sea voyages, forcing him to exist on non-perishable foods such as dried biscuits and salt pork, there has been recognized a disease known as scurvy. It is indicated by bleeding from the mouth and nose, swelling of the gums and tongue, loosening of the teeth, discoloration of the skin and extreme depression in spirits. As a cure and preventative there has been used with great success fresh fruit and vegetables and especially the juice of lemons and oranges. We now know through experiments carried out on the guinea pig and monkey that cure and prevention are due to a third vitamine called vitamine C or the anti-scorbutic vitamine. It is very easily destroyed by heat, so that canned materials with the exception of tomato are usually free from it. Potatoes and vegetables if not cooked too long still contain some of it. In cooked meat it is mostly destroyed.

Raw milk is an uncertain source of the anti-scorbutic, but for the infant it usually has sufficient as shown by the unfrequent cases of scurvy where it is used in the infant's diet. By the use of the guinea pig, which is very susceptible to scurvy, much more so than the child, it has been demonstrated that the milk of cows on pasture is more than twice as rich in vitamine C as that of stall fed animals even when getting silage. This variation in vitamine content is partly responsible for scurvy in spring and

late winter, rather than in summer. (See Fig. 10.) Here again the milk cow shows herself to be an efficient concentrator and therefore a good provider of food for man.

MILK PROCESSING

With the widespread attempt, as an economic proposition, to

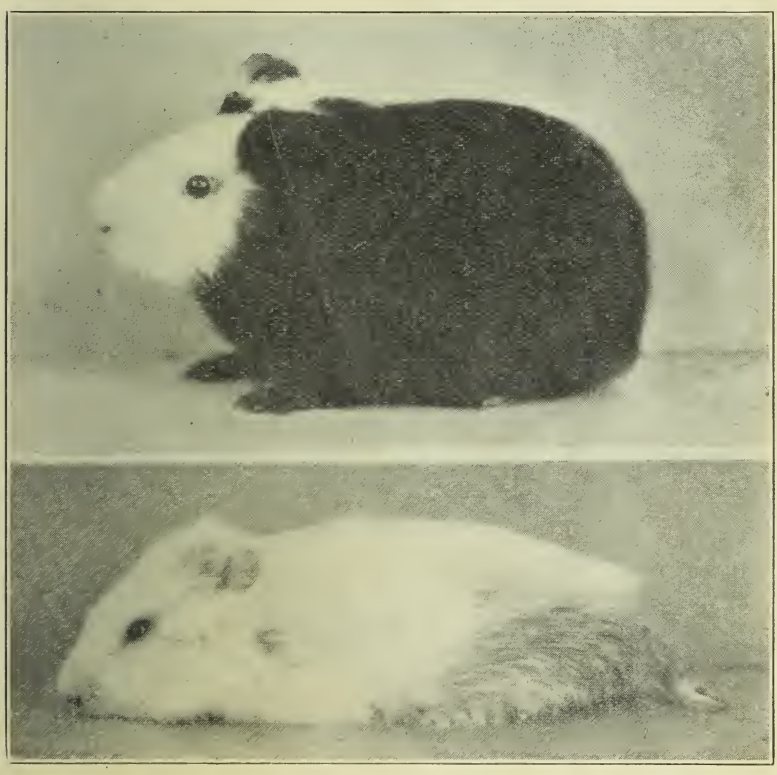

FIG. 10.—EFFECT OF SUMMER AS COMPARED WITH WINTER FEED ON VITAMINE C IN COW'S MILK.

Both guinea pigs received half an ounce of milk in addition to their ration of alfalfa, oats and salt. The upper one, entirely normal, received the milk of cows on a timothy, blue grass, clover pasture. The lower one, afflicted with scurvy, received the milk from cows fed on grains, silage and hays.

extend the use of milk in its various forms, milk has been skimmed, pasteurized, sterilized, dried and condensed. The question, therefore, as to how these processes affect the nutritive value of milk may well be raised.

Skimming milk removes the greater part of vitamine A so that

skimmed milk does not provide an animal with a sufficiency of this necessary food constituent. The same criticism is, of course, to be applied to the so-called "filled" milk.

"Filled" milk is an evaporated milk from which, previous to evaporation, all the butter fat has been removed and then an equivalent amount of vegetable fat such as cocoanut oil is mixed in. As most of the vitamine A is removed with the butter fat and then a fat free from the vitamine substituted, there results a product deprived of one of the principal virtues for which milk is to be recommended.

The use of "filled" milk for infant feeding is intolerable and should be prohibited by law, but as many mothers of limited means do not know the dangers of "filled" milk they are bound to use it when available. In the interest of public welfare it is even desirable to entirely prevent its sale and manufacture. Certainly the claim of the manufacturer to the legal right to manufacture his product—even if correctly labeled—ought not to be allowed to produce a situation liable to deprive infants of their right to normal growth and health.

Evaporation of whole milk with or without sterilization, as in the making of sweetened condensed milk, does not destroy vitamine A. It is a comparatively stable substance, as even the preparation of dried whole milk leads to but little if any loss of the original value of the milk in this essential.

Vitamine B is a very stable compound. Nothing that can be done to milk while it still preserves much of its taste and appearance is liable to decrease the amount of this vitamine. Sterilizing, drying, and condensing milk do not affect the ultimate content of vitamine B.

Vitamine C, about which we should be chiefly concerned when evaluating processed milk for its vitamine content, is partly destroyed by pasteurization, especially where the milk is agitated and aeration results. Sterilization under similar conditions destroys it completely. Even the aging of milk causes this vitamine to disappear. As a result, unsweetened canned milk where we have a combined intensified effect of these factors, no longer contains any vitamine C. In sweetened condensed milk, however, heat treatment and exposure to air is minimized so that some of the vitamine is preserved. Milk powders differ considerably. Those dried by the spray process contain little if any

vitamine C, while those dried by the roller process are fairly efficient. Present information indicates that it is not safe to use any processed milk for infant feeding for long periods of time without supplementing it with an efficient anti-scorbutic such as orange juice or tomato juice.

Need for Milk in the Diet

Because of the nutritive value of whole milk and its products, it is very necessary that the purchasing public realize the important place the dairy industry should occupy in the life of this nation.

Whole milk is worth more than its energy value; it is the great factor of safety as a supplement to our grains and makes good their deficiencies. It should be used not only liberally in the feeding of children, but also in cookery.

AGRICULTURAL EXPERIMENT STATION
THE UNIVERSITY OF WISCONSIN
STATIONS
MAIN
BRANCH
DEMONSTRATION
+ COUNTY REPRESENTATIVE

Bulletin 343

May, 1922

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Johne's Disease a cattle menace

AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF WISCONSIN
MADISON

DIGEST

The transmissible diseases of plants and animals spread more rapidly as the commerce in plant and animals increases. Diseased plants and animals form a constantly increasing percentage of the total number transferred as the infected centers become more numerous. Pages 3 to 4.

Johne's disease is not wide spread at present, but may become so. Now is the time to fight it. Page 4.

Intermittent diarrhea and emaciation mark Johne's disease. It affects cattle primarily. Pages 4 to 5.

In all the chief cattle raising countries Johne's disease is found. In some it causes considerable losses. Pages 5 to 8.

An organism that grows in the intestinal wall causes Johne's disease. The effect on the animal is to produce a progressive emaciation. A thickened and much wrinkled intestinal wall is the most marked lesion of the disease. Pages 8 to 13.

The organism causing the disease is brought into a herd in the body of a diseased animal. If the disease is far advanced in any of the affected animals, the organism will be given off in great numbers and the disease will spread rapidly in the herd. Pages 13 to 15.

The disease can be detected in the animal by the use of Johnin which causes a temporary rise in temperature in affected animals and has no effect on non-affected animals. Pages 15 to 19.

Repeated tests of entire herds and removal of reacting animals may free the herds from Johne's disease. Pages 19 to 20.

An animal may be affected for a number of years and show no symptoms. The calves of affected animals are undoubtedly free from the disease at the time of birth. Pages 20 to 21.

Johne'sDisease

B. A. Beach and E. G. Hastings

EVERY FARMER REALIZES that diseases both in his crops and herds are more numerous than a generation ago. He may conclude from this observation that new diseases are appearing in the world. So far as our present knowledge goes the conclusion is undoubtedly a false one, but something which is quite akin to the arising of new diseases in its effect on the farmer's business is taking place. This is the continued spread both of plant and animal diseases which have previously been confined to limited areas of the world. Bovine tuberculosis is an example. No one knows where or when it originated, but it is definitely known that through the export of cattle from northwestern Europe during the last eight or ten decades the disease has been carried to all parts of the world. A considerable part of this distribution took place before much was known concerning tuberculosis, and especially concerning its detection. The task of eradicating bovine tuberculosis seems to many, one that cannot be accomplished on account of its present world-wide distribution.

Avian tuberculosis is an example of a disease, the spread of which has taken place in very recent years. It was not known to occur in Wisconsin before 1906. At present thousands of the flocks of the state are tubercular. If the knowledge now possessed concerning both bovine and avian tuberculosis had been available and had been applied while these diseases were still localized, neither would be a serious problem for the present-day farmer.

Since the organisms causing any particular disease are carried from place to place primarily in the diseased animal or plant or in their products, it is evident that with the increase in number of animals and plants shipped from one part of the world to another or transferred from place to place in a more limited area, the spread of any disease gains impetus. If there are few infected centers, the great part of the animals and plants transferred

will be free from the disease. As the centers of infection increase, a greater part of the individuals transferred will be diseased and hence, again, the spread of the trouble will be accentuated.

Johne's disease, the subject of this bulletin, is one that is not at all widespread in Wisconsin or in any part of our country at present. It does occur, however, and as the years go by it will become more and more common and will place a greater tax on the cattle industry unless some consideration is given to it by those engaged in the raising and sale of cattle. It is not a new disease, but one which until recent years was confounded with other diseases. Its cause was discovered in 1895. The disease was first found in this country in Pennsylvania in 1908. The purpose of this bulletin is to call it to the attention of those interested in the cattle industry in order that steps may be taken to protect the herds still free from it and that the few herds now affected may be freed from the disease. A little work done now may have far more effect than a hundred times as much a decade hence, if inferences can be drawn from the experience of other countries with this disease.

The successful fight against any transmissible disease necessitates some means of detecting it at such an early stage in its development that the affected animal can be removed before the disease-producing organism has spread to other animals. Such methods are now available for Johne's disease. They are herein described and the experience which the Experiment Station has had with them is presented. The struggle against this disease as against any other is one which the breeders must carry on, each for himself with such aid as the state may be able to give.

CHARACTERISTICS

The disease affects cattle and, in rare instances, sheep and goats. It has been found in deer. The affected animals lose flesh very slowly until they become virtually walking skeletons. The unthrifty condition of animals, in spite of abundant feed, is occasioned in part by this disease. Tuberculosis is another cause of the condition that makes the common English term, "piner", a fitting one. The term "canner", referring to the use which is made of the meat in the packing houses, is the more common American term applied to sick emaciated animals. It is believed that once Johne's disease is under way

in the animal, death is certain to result from it. The progress is so slow that its contagious nature is usually not recognized since one usually thinks of a transmissible disease as progressing rapidly to death or retrogressing quickly to recovery.

The disease is known under a number of names. The one used in this bulletin is the most common and owes its origin to the discoverer of the organism. Paratuberculosis is used by

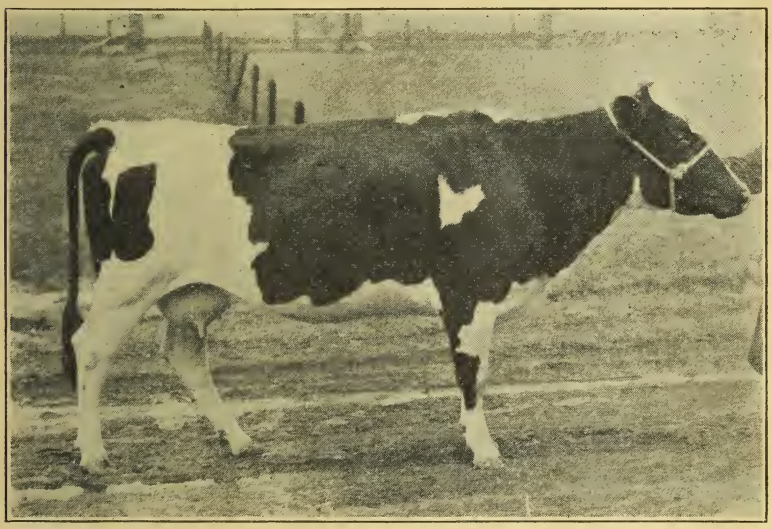

FIG. I.—AN INFECTED ANIMAL.
This animal reacted to Johnin.

some writers, chronic bacterial dysentery by others, while in Norway the trouble is known as Laaland's disease, because of its prevalence on the Island of Laaland, a part of Denmark. The common Swiss name for the disease is "Kaltbrandigkeit", which signifies a thirst without fever. The thirst is due to the watery condition of the feces. In England and Scotland the disease as it occurs in sheep is called scrapie.

OCCURRENCE

The disease causes considerable losses in several European countries. No definite data as to the extent of the losses are available. In Denmark the disease was first recognized in 1904 by B. Bang in two cows of the red Danish breed, the cattle most widely kept by Danish farmers The disease has also been found

in the Jutland breed, while it is especially important in the Jersey herds of Denmark. Its widespread occurrence in this breed gave rise to the statement by B. Bang that the future of this breed of cattle in Denmark depends on the ability to eradicate Johne's disease from the herds. In Denmark 3.5 per cent of the total value of the cattle insured by one company was paid yearly for losses due to this disease. It has caused great losses in Switzerland, and in Germany, and is quite widespread in England and in the Channel Islands It has been estimated by those most familiar with the conditions in England that 1 per cent of the cattle are affected. In Birmingham, England, on the average six cases are found in each 1,000 cattle killed in the municipal abbatoir. It seems quite probable that the occurrence of the disease in the Jersey herds of Denmark reflects the condition in the island of Jersey. In our experience some of the Guernsey cattle imported from the island of Guernsey have been found affected.

The trouble was first recognized in this country by Dr. Leonard Pearson of Philadelphia in 1908. Little can be said of the extent to which the disease occurs here. It has been reported to us from eight states. It seems probable that the conditions in other of the important dairy states will be much the same as in Wisconsin. It is impossible to obtain data that will enable one to make even an estimate of the number of affected herds in Wisconsin. Definite knowledge of its occurrence in 18 herds in 13 different localities has been obtained. It is certain that the disease is more widespread than our present data indicate. The disease is not recognized by many practicing veterinarians. Opportunity to make a post mortem examination is rare in the case of this disease, due to its slowly progressing nature and the opportunity thus presented to the owner to sell the animal for slaughter.

The prevalence of the disease is not such as to cause great alarm, except that it is likely to be present in pure bred herds from which animals are being sold in great numbers. A few such distributing centers may in a few years infect many herds and the disease will thus spread with a constantly increasing rapidity unless more attention is paid to it than is done at present.

The extent to which the disease may spread in a herd is shown by the results of O. Bang who examined a considerable number of herds, using tuberculin prepared with the avian tubercle bacillus. The danger of confusing tuberculosis and Johne's disease was avoided by testing only cows that had not reacted to ordinary tuberculin. Table I. was compiled from the data collected by Bang. The extent to which a herd may be affected is comparable to that found with tuberculosis.

TABLE I—THE EXTENT TO WHICH JOHNE'S DISEASE WAS FOUND IN SOME DANISH HERDS

Herd	Number of animals over two years old	Infected	Number of animals under two years old	Infected
		Per cent		Per cent
1	139	45.3	31	0.0
2	69	37.7	25	0.0
3	67	34.5	26	4.0
4	148	10.8	73	5.5
5	99	10.0	78	10.0
6	291	13.0	77	8.0
7	85	23.5	29	0.0
8	89	9.8	19	0.0

IMPORTANCE

The importance of a disease is measured to a large extent by the number of herds affected, and by the proportion of the diseased animals that succumb to it each year. The decreased productivity of diseased animals is also to be considered. In many instances the highest producers of the herd seem to be the ones affected. A case in point is the following. Seven young cows and heifers were found affected in a herd that came under our observation. The five highest producers of the herd were found among these diseased animals.

The importance of the disease is made more real when the actual losses from herds are presented. The losses in five dairy herds concerning which we have been able to secure rather complete histories are presented in Table II.

TABLE II—LOSSES FROM JOHNE'S DISEASE IN A NUMBER OF WISCONSIN HERDS

	Number in herd	Duration of infection	Number removed because of infection	Yearly losses
1				
2	45	8 years	30	8.5%
3	50	17 years	41	4.7%
4	40	15 years	20	2.2%
5	35	10 years	22	6.2%
	18	10 years	22	12.0%

An annual loss of from 2 per cent to 12 per cent over a period of years is a serious matter to the breeder. It is a tax from which he may well attempt to escape.

CAUSE

The organism causing the disease is one of an important group of bacteria. The other disease-producing members of the group are the human tubercle bacillus, the bovine tubercle bacillus, the avian tubercle bacillus and the organism causing leprosy. These organisms have certain common properties, one being their very slow growth both in the animal body and in the artificial cultures in the laboratory. None of the diseases mentioned is of an acute nature; the organisms named and the Johne's bacillus have much the same appearance under the microscope. Indeed the Johne's bacillus cannot with certainty be recognized from the tubercle bacillus in the microscopic examination of specimens from cattle. It was at first thought to be the avian tubercle bacillus which when growing in the tissues of cattle produced lesions unlike those which it produces in the tissues of the bird.

Johne's bacillus undoubtedly enters the body of the animal through the food and drink. It finds favorable conditions for growth in the wall of the intestine and in the neighboring lymph glands. The bacilli may be found in enormous numbers in the affected tissues of some animals, while in the tissue of other animals, their presence is detected with great difficulty. During the early stages of the disease it is probable that the organism is so confined within the tissues that it is unable to get out of the body of the affected animal. As the disease progresses, the organisms get into the intestinal contents and are excreted in the feces. Opportunity is therefore presented for them to be swallowed by a healthy animal.

It is not certain whether the evident symptoms of the disease precede this excretion or follow it. If the former condition is true, then the removal from the herd of any animal that shows physical symptoms should prevent the spread of the disease in the herd. From what is known of other diseases, it seems

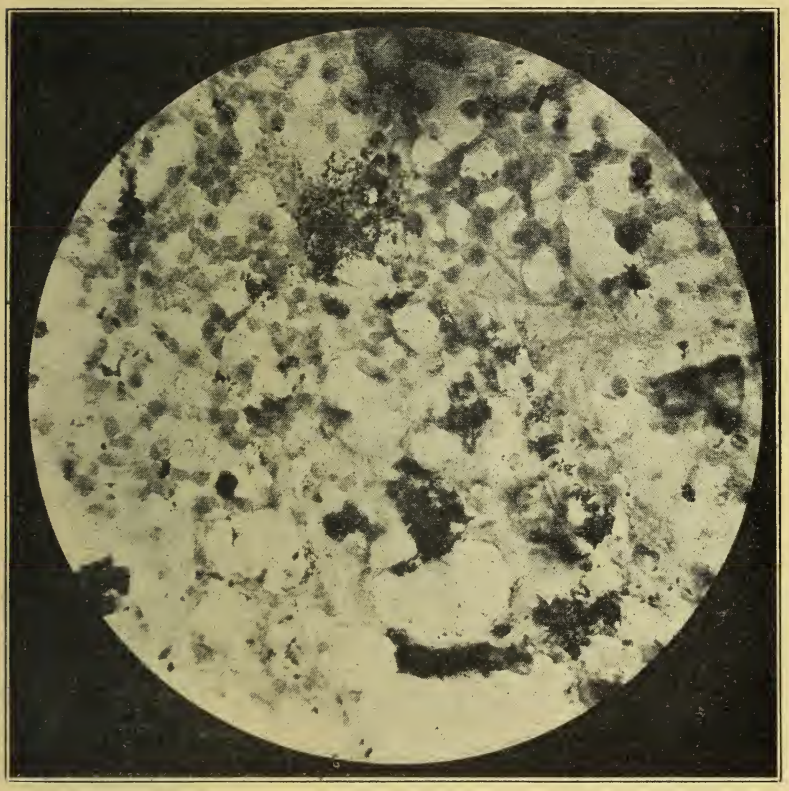

FIG. II.—A PHOTOMICROGRAPH OF A SECTION OF A DISEASED LYMPH GLAND.
The dark areas consist of masses of Johne's bacillus.

probable that the organisms are excreted before any certain symptoms are evident. This implies that some means of detecting the disease in its early stages is essential in combating its spread both in the herd and from herd to herd.

The ability to grow the causal organism of any disease is likely to be of great assistance in gaining information of value concerning the disease, and especially in detecting it in the

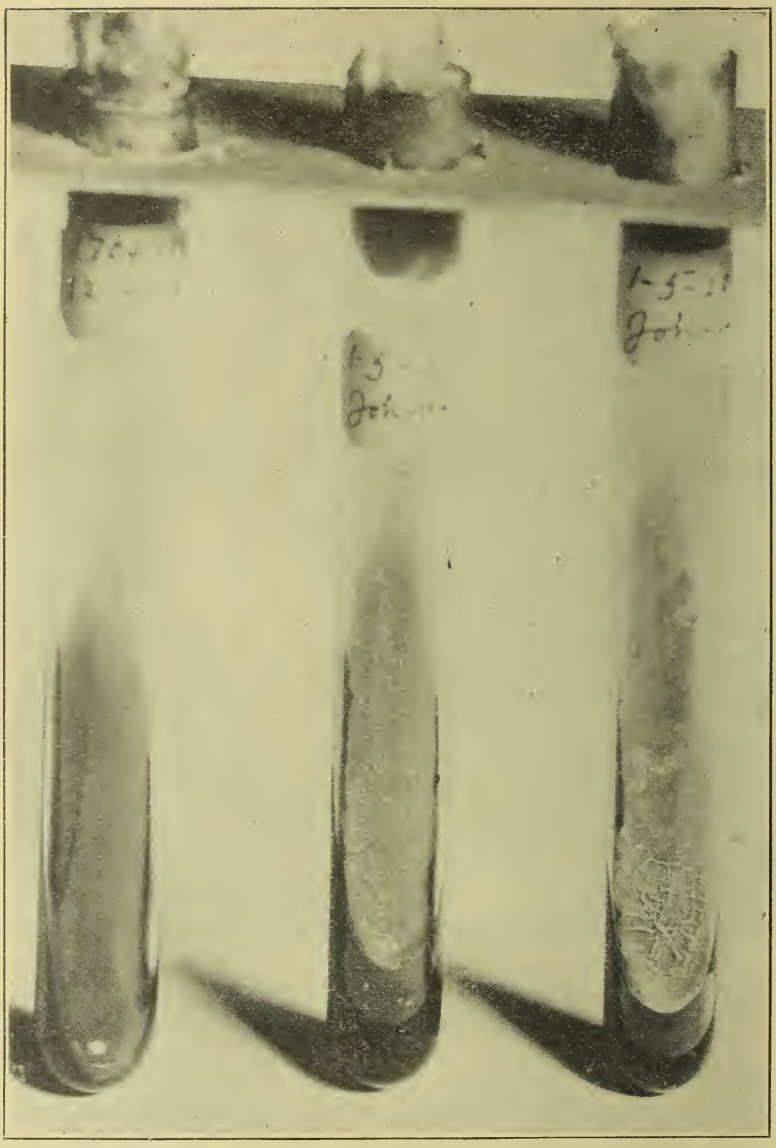

FIG. III.—GROWTH OF JOHNE'S BACILLUS.

The tube on the left shows the meager growth obtained when the culture was first isolated, the other tubes the more profuse growth when the organism had become better adapted to artificial culture media.

early stages. The organism of Johne's disease was not grown in artificial cultures until 1910 and even at present its isolation and continued cultivation is a very difficult task in which the failures far outnumber the successes.

SYMPTOMS

The physical symptoms are slow to develop after the invasion of the animal by the organism. From observations that have been made in England it seems that at least six months must elapse after invasion before symptoms ever become evident. This implies that the disease is not likely to be noted in young animals. Heifers with their first or second calf are more apt to show symptoms than older or younger animals. The strain placed on the animal by pregnancy seems to accentuate the progress of the disease which may have been acquired in early life.

The most striking symptom is the gradual loss of flesh. This continues until the animal becomes a mere skeleton. The eyes remain bright but become sunken due to absence of intra-orbital fat. The milk flow is reduced and finally ceases altogether. Commonly no fever is present and the appetite is not impaired. These conditions are similar to those noted in tuberculosis, especially as it occurs in birds. The first suspicion is of tuberculosis. Marked emaciation and nonreaction to tuberculin should lead to a suspicion of Johne's disease.

The other most marked symptom is a diarrhea which appears and disappears to appear again sooner or later. In the later stages of the disease the diarrhea may be constant and again it may be entirely absent. It should be recognized that there are numerous causes of both marked emaciation and diarrhea. These symptoms become indicative of Johne's disease only when coupled with the characteristic lesions. As has been mentioned before, the appearance of the symptoms is so slow that the suspicion of the owner in regard to a contagious disease is not aroused. Often the infection has an opportunity to become widely disseminated in a herd before serious consideration is given.

In the great majojrity of infected herds but one or two animals are lost per year. This again tends toward the thought of a non-contagious trouble.

POST MORTEM FINDINGS

The lesions found in the tissues of an animal that has died from Johne's disease are usually insignificant as compared to

the physical condition to which the animal is reduced. In many instances the extent of lesions bears no relation to the emaciation or to the diarrhea that the animal shows. Cases of long standing may show very little evidence on post mortem, while in others the tissue changes are comparatively quite marked. It seems certain that this non-relation between the extent of lesions and the condition of the animal has caused many cases of Johne's disease to pass undetected by the examining veterinarian. The lesions of Johne's disease will rarely be discovered unless the intestine is slit and the inner wall examined. In the cases examined by us in which the lesions were insignificant, the organisms have been found by microscopic examination.

The only characteristic lesion is the thickening of the intestinal wall. This may vary widely both in extent and degree. Only a

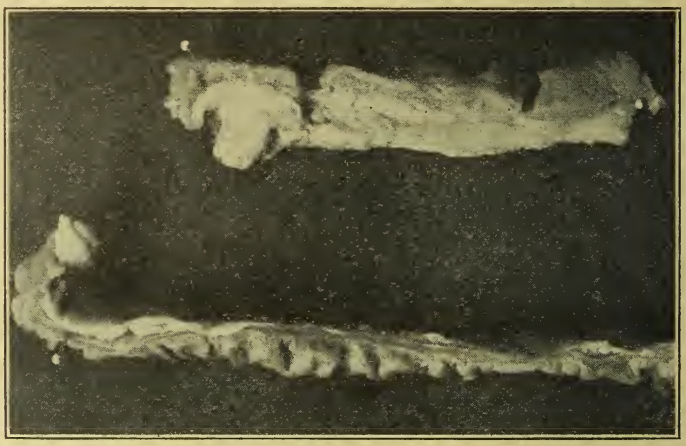

FIG. IV.—HEALTHY AND DISEASED INTESTINAL WALLS.
The intestines were slit open and the cut edge photographed. The one at the bottom represents the thickness of the normal wall, that at the top the thickening due to the growth of Johne's bacillus.

short portion of the tract may show the thickened condition, while again it may extend for many feet. It is most often noted at the opening between the large and small intestine, the ileo-caecal valve. It is here that the change is likely to be most marked. The thickening of the wall results in more wrinkling than is noted in a normal wall. In the normal intestine the folds will disappear when the wall is stretched, while they are permanent in the case of the diseased intestine. The wrinkled condition may occur in patches rather than in a continuous area.

The tissues near the ileo-caecal valve may be swollen and greatly inflamed. There are, however, no hemorrhages nor do ulcerations occur. The mesenteric lymph glands usually appear moist when cut and often a little swollen.

MODE OF SPREAD FROM HERD TO HERD

There is no reason to believe that the disease is transmitted from herd to herd other than through the transfer of an affected animal. Animals may be infected and yet show no symptoms

FIG. V.—HEALTHY AND DISEASED INTESTINAL WALLS.
The upper part of the picture represents a normal wall when tightly stretched, the bottom part the wall of an animal infected with Johne's bacillus. It is impossible to remove the wrinkles of the diseased wall by stretching it.

for many months. The seller may have no reason to believe that the animal is other than healthy and so is, as far as the individual animal is concerned, perfectly innocent. Until recently most owners of affected herds have not realized the contagious nature of the malady which was causing them more or less con-

tinuous losses and were again perfectly innocent of any wrong in the sale of animals. At present it is feared that as much cannot be said for all breeders.

The history of a number of affected herds has been obtained with such completeness that the original source of infection could be traced. Without exception a purchase from an infected herd has been the origin of the trouble. The best protection of the buyer is inquiry concerning the general healtth of the herd, and concerning the nature of losses that have occurred, rather than inquiry concerning the individual to be purchased. A general statement concerning the health of the entire herd should be required by the purchasers at any consignment sale of cattle.

RATE OF SPREAD IN INDIVIDUAL HERDS

The rate of spread is dependent on the number of animals excreting the causal organism and the number of organisms given off by each animal. It is also influenced by the conditions under which the animals are kept. Since the organisms are given off in the feces and enter the body of healthy animals in the food or drink, any method that tends to soil the food with manure will hasten the spread of the disease. Yard feeding will favor the dissemination to a greater extent than stall feeding. The keeping of calves in yards with older cattle would seem to be bad practice, since in this way what seems to be the most susceptible part of the herd is brought in contact with the portion that may be excreting the organisms.

The following are some of the cases that have come to our attention: A dairyman purchased three young cows at a sale in 1910. The animals were in good condition at the time of purchase. In 1912 two of these cows became poor; they had diarrhea at intervals and were sold as canners. In 1913 the other animal showed symptoms and was sold. In 1914 an animal of his own breeding was sold because of her condition. Up to 1920, 15 head have either died or have been sold for slaughter because of Johne's disease. The average size of the herd during this ten year interval was 18 head. When the herd was first tested in 1920, seven reacting animals were found in the herd of 18.

Another dairyman purchased a two-year-old heifer with her first calf in October, 1910. This heifer had been imported four months. At the time of purchase she was thin in flesh. The owner, who was unacquainted with Johne's disease, attributed her

condition to other causes. This heifer died the following March. At the time the heifer died, two others were scouring badly and were sold. Still another was isolated and died in August, 1911. Up to 1920, 20 head have been lost from this herd of 35 to 40 animals. These were mostly heifers with their first or second calf. None were under two years old and the symptoms were shown always just after calving, during the period of heaviest milk flow. In this herd also, many of the highest producers were taken. One interesting observation in connection with this herd was the fact that a middle aged or old animal has never shown symptoms of Johne's disease.

In 1913 a dairyman bought four heifers. Among them was a yearling which developed in a normal manner as far as was observed. In 1919 this cow exhibited symptoms of Johne's disease and was sold. It seems probable that the infection was introduced in this yearling heifer. A few additional animals were purchased but no history of Johne's disease could be found in the herds from which they came and they have not since developed it, and are still in the herd. No animal which had been raised on the place and sold between 1913 and 1919 was in an unthrifty condition when sold. These facts indicate that the infection was inactive in this heifer for six years and then became active. During the past two years two additional cases have developed in this herd.

A breeder of purebred dairy cattle purchased a bull in 1903. This bull became thin and died of Johne's disease in about one and one-half years after reaching the farm. Up to the year 1917 this herd has lost 20 head. One noteworthy observation on this farm was a 10-year-old cow that exhibited symptoms of Johne's disease. The specific organisms were found on postmortem.

THE JOHNIN TEST

It has been pointed out that there is opportunity for the disease to be transmitted by an animal before the condition of the animal is recognized. The recognition of this fact has been the stimulus to seek for more perfect methods of detecting the disease in its early stages before the organisms have been given off.

The supposed relation of the avian tubercle bacillus to the disease led to the use of tuberculin prepared with this organism. The results obtained by various workers were fairly satisfactory. The cultivation of Johne's bacillus by Twort and Ingram of England

in 1910 enabled them to prepare a product similar to tuberculin in its mode of manufacture and use and in its effect on the diseased animal.

The preparation of the Johnin, as the diagnostic agent is called, is briefly as follows: The organisms causing the disease are grown in a specially prepared beef broth for at least three months. The flasks containing the cultures are heated in order to kill the organsims; and a small amount of carbolic acid is added as a preservative. The product thus consists of an extract of the organism. It will contain some of the dead bacilli. It is, of course, impossible for it to cause the disease since any organisms that it contains have been killed by heating.

A large percentage of cattle infected with Johne's disease when injected with Johnin will respond with a rise in temperature, muscular tremors, or diarrhea. In order to get the best results with this agent it is necessary to inject the Johnin into the blood stream. The manner in which this test is conducted is as follows: The cattle to be tested are confined and handled in the customary manner. The surroundings should be such as to cause as little excitement as possible, since the results of the test are based largely on a rise in temperature. Any outside influences, therefore, that tend to cause variations in temperature may give rise to erroneous results. Feed and water should be as usual except that water should be given just after a temperature is taken and not just before, as large quantities of cold water lower the temperature for a little while. One or two temperatures are taken before the injection of the Johnin. Any animal with a temperature higher than 103 degrees should not be tested. If there are any animals in the herd with a high temperature without apparent reason, such as recent calving, vaginal discharge, garget, etc., none of the animals should be tested at this time. Leaving those with high temperatures and testing the remainder is poor practice for the reason that the same factor that is causing the high temperature, may at some time during the test cause a fever in animals that at the beginning showed a normal temperature.

The head of the animal to be injected is secured with a halter as high up as possible and to one side. A rope is placed around the neck just in front of the shoulders and drawn taut enough to distend the jugular vein. For the average cow 10 cc. are injected into the vein. Cows showing symptoms should receive 15-20cc. If possible the first temperature is taken within thirty

minutes after the injection of the Johnin. Temperatures should then be taken every two hours up to and including the 12th hour. Care should be exercised to deposit the Johnin in the blood stream, for if it is injected into the tissue around the vein, the reaction may fail to develop in the usual manner. The extent of the rise in temperature is much the same as in the tuberculin reaction. Usually the rise and fall of temperature is gradual. Figure VI shows typical reactions to the Johnin test.

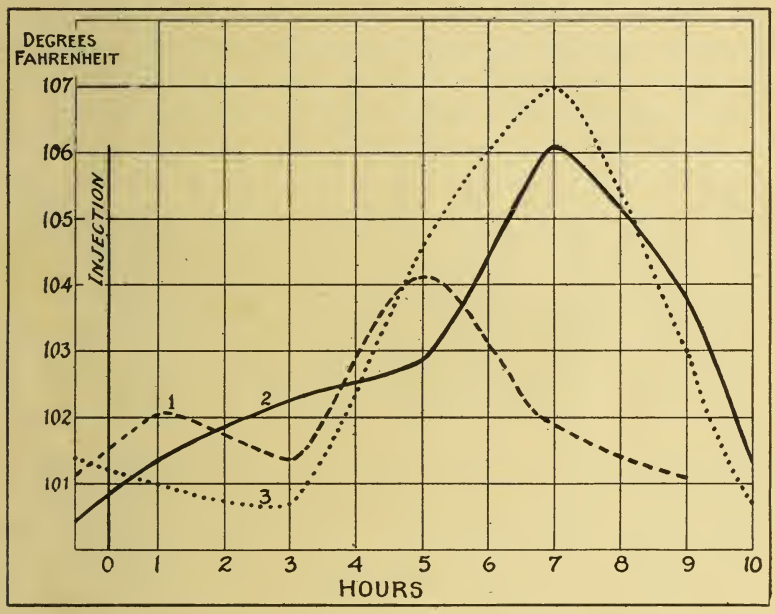

FIG. VI.—REACTION CURVES.

The temperature curves of three animals. It is to be noted that the maximum temperature is reached more quickly than in the tuberculin test, although the height of the reaction is very similar.

The initial increase in temperatures may come at any time between thirty minutes and ten hours after injection. The third to the seventh hour is the usual time for the temperature to start rising if a reaction is going to take place.

The following table shows the hour at which the highest temperature was reached in 79 head which reacted to the Johnin test:

TABLE III—HOUR AT WHICH MAXIMUM TEMPERATURE WAS REACHED AFTER INJECTION OF JOHNIN INTO DISEASED ANIMALS

Hour after injection	Number reacted	Per cent	Hour after injection	Number reacted	Per cent
1	None	None	7	18	22.7
2	None	None	8	4	5.5
3	8	10.12	9	1	1.16
4	5	6.32	10	3	3.70
5	34	43.	11	1	1.16
6	5	6.32	12	None	None

It will be seen from the data that approximately 80 per cent of the highest temperatures fell between the fifth and eighth hours.

As in the tuberculin reaction there is considerable variation in the maximum temperature reached by the reacting animal. The character of the reaction gives no idea as to the extent of the disease. Animals in the last stages of the disease often fail to react. It is necessary, therefore, to take this fact into consideration in dealing with infected herds.

TABLE IV—PERCENTAGE DISTRIBUTION OF REACTING ANIMALS ACCORDING TO MAXIMUM TEMPERATURE ATTAINED ON INJECTION OF JOHNIN

Maximum temperature	Number	Per cent
103-104° F.	26	31.3
104-105° F.	35	42.1
105-106° F.	11	13.2
106-107° F.	8	9.6
107-108° F.	3	3.6

A summary of the maximum temperatures reached by reacting animals is presented in Table IV, from which it appears that the majority of reactions reach their maximum between 104 and 106 degrees F.

This test should not be attempted by other than a skilled veterinarian. The success or failure is determined largely by the expertness of the operator in being able to deposit the Johnin into the blood stream and not in the tissue around the vein. The injection of the Johnin beneath the skin, as is done with tuberculin, does not give good results.

Muscular tremors and a diarrhea are frequently shown by reacting cattle.

The diagnostic fluid, Johnin, was first prepared and used by the Englishmen, Twort and Ingram. In their work the test was applied only to animals that had been artificially infected with

the disease organism or to animals that showed symptoms of the disease. No effort was made to test an entire herd, and to determine thus all or part of the infected animals, the removal of which from the herd should tend to decrease the disease and possibly to actually free it from the infection.

FIRST APPLICATION OF JOHNIN FOR HERD TREATMENT

In 1915 we were fortunate enough to isolate a culture of the organism from tissue submitted to us for diagnosis. Johnin was prepared and through the assistance of the State Department of Agriculture and of a number of breeders whose herds were known to be infected, efforts have been made to determine the value of the agent. More than one thousand cattle have been tested.

In any such test it is evident that errors may occur in two ways. Non-infected animals may react to the test or infected animals may fail to react. The latter is the more serious error when one is interested in freeing a herd from the disease. It is also an error that only long continued testing of an infected herd can evaluate. The other error can more easily be measured by the detection of lesions of the disease or the causal organism in the tissues of reacting animals.

It has not been possible to obtain a post mortem examination on all of the animals that reacted to Johnin. Such observations have been made on thirty animals. In twenty-nine clear evidence of the disease was found. It would thus seem that few if any non-infected cattle are so affected by the Johnin as to be classed as having given a reaction. The Johnin test seems as accurate as the tuberculin test in this respect.

The evidence that has been accumulated in connection with the other error, the non-reaction of infected animals, is small in amount. One herd in which the disease had been known to be present for a number of years has been tested nine times in the period from June, 1917, to December, 1921. Reactors have been found in all except the last two tests. A summary of these tests is presented in Table V.

TABLE V—SUMMARY OF RESULTS ON CONSECUTIVE TESTS OF AN INFECTED HERD

Date of test	Number tested	Number reacted
June, 1917	43	5
December, 1917	53	4
February, 1919	51	6
June, 1919	49	4
February, 1920	52	4
June, 1920	54	4
November, 1920	47	6
June, 1921	55	None
December, 1921	51	None

It is impossible to tell at this time whether the herd is actually free from the disease or not. Further tests are needed to demonstrate this. One encouraging fact is that none of the cattle have shown symptoms of this disease since the first test was made. This means that the test is detecting the disease before symptoms become evident.

If it should prove that the test will detect the trouble before the organisms are eliminated, there would remain no doubt concerning the marked diagnostic value of the Johnin. Without the test the infected animals remain in the herd until the disease becomes far advanced with the probability of continued spread of the infection. When the test is employed what seem to be healthy animals are removed, probably before the infection has opportunity to spread from them. In either instance the owner faces loss. If visibly diseased animals remain in the herd, the loss becomes continuous. With some means of early detection, losses from the disease should decrease and finally stop.

Seven herds have been tested during a shorter period of time. The observations are not extended enough to warrant any statement as to the results. It is only through the co-operation of the breeders and veterinarians that the value of these methods can be determined by the Experiment Station. The writers will appreciate any information concerning suspected herds.

In but one instance have clinical cases appeared in any of the tested herds.

DURATION OF DISEASE IN INDIVIDUAL ANIMALS

With Johne's disease, as with tuberculosis, the infection may be present for long periods before symptoms become evident. In one of the animals that came under our observation the infection had apparently been present for six years. In another herd a

cow has been reacting to the Johnin for three years, and at present shows no symptoms of the disease. This fact makes it reasonably certain that eradication by elimination of those animals showing symptoms would, in most instances, not be successful.

It is not to be inferred from this that removal of clinical cases will have no effect in decreasing the disease. O. Bang informs us that the disease is apparently less prevalent in Denmark than a few years ago and offers as an explanation the more careful watch of the herds, and the prompt removal of animals showing symptoms. It is evident to the writers that this is the method that must be followed to a great extent in this country. Prompt removal of all suspicious animals from the herd and care in the purchase of animals will certainly do much to limit the continued spread of this disease. In the purebred herds the use of the Johnin test seems advisable.

TRANSMISSION FROM DAM TO CALF

There is no reason to believe that calves of infected dams are infected at birth. The close association of the calf with an infected mother gives opportunity for the young animal to acquire the infection and to develop the symptoms later, most commonly soon after the first or second calving. The prompt separation of calf and dam will, undoubtedly, prevent the infection of the former, as it does in tuberculosis.

SERUM SICKNESS

It is necessary to add to the broth in which the Johne's bacillus is to grow a small quantity of the serum from horse blood. Whenever a small quantity of the serum from one kind of animal is injected into the tissues or the blood stream of a different kind of animal, the treated animal becomes sensitive to a second dose of the same kind of serum. The first application of the Johnin test causes no disturbance in non-infected animals, while infected animals give a reaction as has been described. On a second test of the same animals some disturbance may be noted in all animals. It manifests itself in rapid breathing and drooling from the mouth and nostrils. A swelling of the soft tissues may occur, especially around the eyes, the anus and vulva, and udder. The extent of the disturbance varies markedly from animal to animal. It may be so slight as to pass unnoticed in many, while in a few prostration may occur. There is no rise in temperature. The symptoms

of "serum sickness" last but a few hours, and do not complicate the true reaction of an infected animal to Johnin. It is probable that serum sickness can be avoided by the use of cow blood serum in the preparation of Johnin.

The authors desire to acknowledge the assistance of Doctors O. H. Eliason and W. R. Claussen, of the Wisconsin State Department of Agriculture, in carrying out the work presented in this bulletin.

THE old adage, "an ounce of prevention is worth a pound of cure—" applies especially to Johne's disease or chronic dysentery of cattle, an affection which is found in comparatively few herds at the present time. Like tuberculosis, it progresses very slowly in the animal, which therefore, may show no evident symptoms for many months after the disease is established in the tissues. The transfer of such an apparently healthy, but really diseased, animal from one herd to another is very likely to produce another center of infection from which the disease may spread to other herds. The rapidity of distribution of the disease increases as the centers of infection increase.

The aim of this bulletin is to call the attention of the veterinarians and breeders to Johne's disease, which, it is felt, is not recognized by many, in order that steps may be taken to prevent its introduction into still healthy herds, and to gradually eliminate it from affected herds.

The disease can be detected by the use of a product, Johnin, which is made with the organism causing the disease, and which is similar to tuberculin in its mode of application and effect on healthy and diseased animals. This test is still in an experimental stage. Over one thousand cattle have been tested. The disease was found on post mortem examination in 29 out of 30 reacting animals. Whether all affected animals can be detected by the test can be determined only by a long series of tests on diseased herds. Only one such attempt has been made; one herd has been tested nine times in four years. No reacting animals were found in the tests made during the fourth year. It cannot be asserted that the herd is free from the disease, but the indications are that it is.

That much can be done to decrease the spread of the disease in a herd by prompt removal of animals showing symptoms, has been demonstrated in Denmark.

That much can be done to prevent the introduction of the disease into a herd by inquiry concerning the health of every herd from which animals are purchased is self-evident.

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Better Cherry Yields

AGRICULTURAL EXPERIMENT STATION
OF THE UNIVERSITY OF WISCONSIN
MADISON

Digest

The profitable production of sour cherries depends upon creating proper growth of the trees. As spur blossom buds are hardier than lateral blossom buds, the securing of a crop often depends upon the numbers of spur blossom buds on the tree. Page 3

Base the cultural treatment upon the growth made by the trees. Since a certain amount of growth is necessary for regular, large yields, the amount and kind of culture and fertilizer should be based upon the way the trees grow. Page 3

The use of fertilizers is necessary. Under the conditions in the Sturgeon Bay district it appears that added fertilizer is necessary to secure maximum production. This seems to be especially true of older bearing orchards. Page 3

It seems advisable to cultivate the cherry orchard after harvest. There is evidence that this would help the amount of growth, size of fruit, and hardiness of the blossom buds. Page 4

Pruning is necessary for maximum yields. A lower top, uniform vigor of wood and increased growth cheapen production and help to give larger crops. Page 5

Heavy pruning did not reduce the yield of the trees. A larger percentage of set after pruning gave a larger crop than on unpruned trees. Page 11

The tree yields are more closely related to the growth of the trees than to any special cultural treatment. Page 13

Low yielding trees are not taking an off year; they are persistently unfruitful until forced to make more growth. Page 15

Winter injury of the blossom buds is related to the growth and bud development. Within limits, the more growth, the hardier the buds. Page 17

Sour cherry blossoms are self fertile. That is, they set fruit when self-pollinated. Page 21

Setting of the fruit is related to tree nutrition. The stronger growing trees have a higher percentage set than weaker trees. Hence, the cultural treatment affects the set of fruit by varying the nutrition and growth. Page 22

The results from a cultural treatment appear from two to three years after the treatment. For example, a strong growth produced one season forms spurs the next and only in the third season does it bear fruit. Page 29

Better Cherry Yields in Wisconsin

R. H. Roberts

Sour cherries yield well when the trees grow well. If the trees are allowed to make a poor growth, low yields result. When the trees are forced to grow vigorously, large, regular yields can be expected. However, stated cultural practices cannot be expected to give the growth necessary for profitable production. This is because the growth and yield of a tree in any one year is influenced, not only by pruning, cultivation, fertilization, soil nutrients, the stock upon which it is grafted, the presence of insects and diseases, and the weather, but also by the results of treatments in past seasons. For example, the amount of growth made by a tree largely determines the number of spurs it produces. These, in turn, regulate production in some seasons, as large crops are wholly dependent upon leaving many spur blossom buds. (Fig. 1.) As growth and yield are correlated, the growth of the trees should be made the basis of the culture given the tree.

Base Cultural Treatment Upon Way Trees Grow

This way of deciding how to care for the orchard seems to apply to almost any condition of tree, but particularly to individual low-yielding trees, as in this case, also, there is a relation between the productiveness of the trees and the way they grow.

The amount of growth desired is such that many spurs will be produced. In general, fifteen to eighteen inches of growth should be made by the majority of the terminal branches and main laterals, according to observations of the growth made by heavily yielding trees and orchards. Using this same source of information as well as the results from experimental plats, the following general suggestions as to cultural treatments are made.

Regular Applications of Fertilizer Seem Necessary

Heavily yielding orchards in general are fertilized regularly, although the types and amount of fertilizer vary. Manure gives excellent results with cherries, but if this is not available commercial fertilizer can be substituted with good results. There is

little evidence that potassium or phosphorus help the trees much under the conditions in the Sturgeon Bay district; these elements are frequently needed, however, for the cover crop. Readily available forms of nitrogen as nitrate of soda or sulphate of ammonia have given marked results in many orchards. These chemicals are generally used at a rate of about three pounds to the bearing tree and the applications are usually made two to

Fig. 1.—RELATION OF GROWTH TO PRODUCTION.
Note the fruit on the longer two-year growth (A) as compared to the bare branch (B) when less growth is made. Short growths (a) produce blossom buds and some fruit. Longer growths (b) produce spurs and a year later bear fruit (A).

three weeks before blossom time. Nitrogenous fertilizers delay the ripening of the fruit markedly, especially on dense-topped trees. There seems to be little assurance of counteracting this delay by using other chemical elements in the fertilizer. Also it seems that this delay can not be avoided if the trees are to be kept sufficiently vegetative to produce maximum crops.

CULTIVATE UNTIL AFTER HARVEST

Cultivation should be continued until after harvest time, from the standpoint of better production. Observations show that cul-

tivating after the first of August does not keep the wood growing too late in the season or prevent the securing of a sown or weed cover crop in the early fall. In fact, it is desirable to have the trees make more wood growth than is usually secured. In a rainy summer, cultivation would not be necessary, as it is advised largely to conserve moisture. Apparently, much hardier blossom buds are borne by trees which are kept from "maturing" too early in the season even though the length of growth is about the same. Definite evidence of the effect upon the yield of later cultivation in a year when rainfall was light during the growing season was secured in 1921.

The size of fruit was taken as evidence by which to compare the effects of early and late cessation of cultivation on similar soil types. Table I shows that a loss of 15 to 20 per cent in the yield followed early stopping of cultivation.

TABLE I. EFFECT OF CONTINUED CULTIVATION UPON FRUIT SIZE AND YIELD

Variety	Culture	No. of fruits per quart	Yield reduction
Richmond	Stopped early	296.7	18.0 per cent
	Continued	251.4	
Montmorency	Stopped early	232.2	19.5 per cent
	Continued	194.4	

PRUNING GREATLY AFFECTS PRODUCTION

From what has been said about the relation between growth and fruitfulness it might be assumed that the abundant use of fertilizer would provide sufficient growth and thus insure high yields. This is only partly true. In the first place, the principal growth responses from the use of fertilizers are found at the end of the main branches. It happens, then, that forcing the trees by cultivation and fertilization without pruning, gives tall trees without increasing production, as the shading by the top branches causes the death of the lower fruiting wood. (Fig 2.) A second reason that fertilization alone is not practical is because pruning has a specific value in keeping the trees productive that cannot be gotten from other cultural practices. This occurs in four ways:

Fig. 2.—UNPRUNED TREES GROW TOO TALL.
Production is not increased as the top wood shades and kills that underneath. Harvesting expense and troubles increase, but production is decreased.

1. Keeping the trees low to reduce harvesting expenses (Fig. 3),

2. Keeping the lower fruiting wood vegetative through thinning that admits light and through rejuvenation cutting (Fig. 4),

3. Keeping the trees "balanced" so strong fruiting wood is produced all over the tree (Fig. 5),

4. Giving individual treatment to persistently low-yielding trees.

The system of heavily heading back cherry trees* is proving of value in sour cherry culture. An especially valuable feature is the markedly better condition of the low fruiting wood. In 1919 no suggestion was offered as to the treatment of the older run-out fruiting wood of mature trees. Some limited experiments as well as observation of practical operations show it is practical and profitable to do some rejuvenation pruning of this wood (Fig. 4).

* *Prune the Cherry Trees.* Wis. Agr. Expt. Sta. Bul. 298.

Fig. 3.—KEEP THE TREES LOW.

Harvesting costs are low and regular high yields are possible. Some rejuvenation pruning might be advisable on the lower wood (Fig. 4). The usual practice is to "let it alone as long as it bears."

Fig. 4.—THE LOWER WOOD CAN BE KEPT GROWING VEGETATIVELY.

Compare with Fig. 3. The best practice has not been determined definitely as yet.

KEEP THE TOPS UNIFORMLY VEGETATIVE

Sometimes one or two branches tend to outgrow the remaining limbs, which soon results in the unfruitfulness or death of the weaker branches. It seems to be best to cut back the strong branches severely, with the result that the other branches are more nearly in "balance" and grow better (Fig. 5). In the case of close headed trees where the lateral branches practically girdle the central one (Fig. 6), there seems to be no way to save this branch.

Fig. 5.—KEEP THE BRANCHES "BALANCED UP."
Large branches as at "A" should be heavily cut back. If this is not done the remainder of the tree becomes weak, bears little and gradually dies. This type of pruning together with proper fertilizing results in a uniformly vegetative top and high production. A typical Montmorency tree.

Objection is sometimes raised to cutting off the strongly growing tops because "this is where the best cherries grow" (Fig. 7). It is better to sacrifice some wood for the benefit of the lower, much larger portion of the top. Heading back pays (Fig. 8).

Fig. 6.—POORLY SPACED BRANCHES GIRDLE THE CENTRAL BRANCH.

(A). This trouble can generally be avoided by keeping the lower branches as (B) and (C) from outgrowing the central one (A). It is too late to remedy the mistake at this late time.

Fig. 7.—THE TALLEST BRANCHES SHADE THE LOWER WOOD.

These vegetative tips produce fine fruit, but so does the lower wood when given light and a chance to grow.

Fig. 8.—HEADING BACK OF THIS TREE WAS DELAYED TOO LONG.
Begin the heading back while the trees are young, (Fig 12). The large cuts made are, however, justified by the profitable production which followed.

The lower tree produced by cutting back the tops may spread more than others and result in crowding between the trees. Cutting back main laterals similar to the cuts in the tops will largely relieve this situation. Such cuts are especially needed for the general benefit of the growth of the lower wood on older bearing trees.

INDIVIDUAL TREES MAY NEED SPECIAL PRUNING

Low-producing trees are generally persistently low bearers and are not having an "off year." Such trees frequently average less than ten quarts a year. It is advisable to give this type of tree a severe cutting back to force a strong new growth and produce a good spur fruiting system.

CULTURAL EXPERIMENTS INCLUDED PRUNING AND FERTILIZING PLATS

The need for pruning in growing sour cherries has already been pointed out. To find out more about the amount of pruning that could be done without reducing the yield and also the amount needed annually, experimental plats were started in Door county

in 1919.* The treatments included heavy and light pruning in comparison with checks on the two principal varieties, Early Richmond and Montmorency. As it seemed to be impracticable to try to secure large yields without the use of some fertilizer, a fertilizer plat was included in the treatments. Three pounds of nitrate of soda was applied annually to each tree on this plat about two weeks before the trees blossomed. All plats received an annual application of two to three tons of stable manure to the acre. All plats were cultivated during the spring and early summer and a weed cover crop was allowed to grow each fall. The trees were eight years old in 1919. They were planted 20 feet apart by the square system.

HEAVY PRUNING DID NOT REDUCE THE YIELD

Two pruning plats were used for each variety. The trees in one plat were given an average amount of cutting, or what would be sufficient to reduce the height somewhat and to keep them sufficiently open to maintain good light conditions in the lower portion of the trees. (Figs. 9, 10 and 5.) A similar, but somewhat lighter pruning was given this plat each of the two succeeding years. The trees in the second plat were pruned very heavily in 1919 to determine the effect of this type of cutting upon yield. Practically no pruning was done in succeeding seasons except to remove a few sucker growths. The reduction in fruiting area, together with the yields secured, are shown in Table II:

TABLE II. EFFECT OF PRUNING UPON YIELD, STURGEON BAY, 1919

Variety	Plat	Percentage of buds pruned off			Percentage of buds fruiting	Yields qts. per tree
		Spurs	Terminals	Tree		
Early Richmond	Check	0.0	0.0	0.0	13.5	13.9
	Heavy pruning	27.4	52.2	37.1	28.8	17.0
	Pruning	17.5	17.5	17.3	19.7	18.0
Montmorency	Check	0.0	0.0	0.0	32.2	36.1
	Heavy pruning	25.4	30.6	27.9	48.8	44.8
	Pruning	15.4	15.4	15.4	34.7	38.2

"Heavy pruning" reduced the fruiting area (the number of blossom buds on the trees) by practically one-third, but the yield on this plat was somewhat larger than on the unpruned trees be-

* A co-operative experiment was conducted with the generous help of L. E. Birmingham, Sturgeon Bay, Wisconsin. The records taken in 1921 were made by A. L. Schrader.

cause of a greater percentage set of fruit. In fact, it appears that the heavy dropping of fruits from unpruned trees consistently reduces the yield below that of either heavily or moderately pruned trees.

Fig. 9.—CUT BACK THE TOP.
This type of pruning lets light reach the lower fruiting wood. It also reduces harvesting troubles and costs. Early Richmond tree. Compare with Fig. 10.

CULTURAL TREATMENT MAY NOT INCREASE THE YIELD

It is usual to assume that the difference between the yield from a "check" plat and from any other plat in an orchard cultural experiment is a fixed and definite measure of the influence of the treatment used. This practice is believed to be wrong for two main reasons:

1. The influence of the previous condition of the trees upon production is not given consideration.

2. It does not allow for individual differences between the trees, which is more or less common to most orchards and is especially important with small plats.

Both of these facts are clearly shown by the data in Tables III and IV. In 1919 the few Richmond trees which were given only nitrate of soda in addition to cultivation, gave the lowest yield, while in the case of Montmorency trees they gave the highest yield.

This does not mean that nitrate of soda is bad for Early Richmond trees and good for Montmorency trees, but rather that the yield during the first year of treatment was largely determined by the previous history of the trees. It would seem, therefore, that a

Fig. 10.—PROPER TOOLS ARE NECESSARY FOR CORRECT PRUNING. Failure to head back and thin out the upper part of the top is often due to lack of equipment. Use a pole pruner or a curved saw attached to a pole. (Same tree as Fig. 9.)

comparison of the yield on the same trees in different years, as at the beginning and end of an experiment, would give a more accurate measurement of the effects of the cultural treatment than merely to compare check and cultural plats. With this idea in mind the ratio or relation of the yield in 1919 to that of 1921 is shown. The results of the treatments when figured in this way, as well as by comparing the yields, are about as follows:

1. Strongly growing, high-yielding trees were kept uniformly productive by fertilizing.

2. Poorly vegetative, low-yielding trees were made to yield moderately by fertilizing.

3. A combination of pruning and cultivation increased the growth and yields.

4. Heavy pruning increased the growth and yields.

5. Moderate pruning without fertilizing gave slight increases in yield.

6. Montmorency trees gave double the yield of fruit of the Richmond trees. This was apparently due in large part to the varietal difference in winter killing of the blossom buds.

TABLE III. YIELD ON CULTURAL PLATS, STURGEON BAY, 1919 TO 1921.

Plat	No. trees	Yield per tree								Relation of yield 1919 to 1921	
		Quarts				Per cent of check					
		1919	1920	1921	Total	1919	1920	1921	Total	Ratio	% check
Richmond—											
Check	8	13.9	9.8	20.4	44.1	100.	100.	100.	100.	1.5	100.
Heavy Pruning	7	17.6	14.7	35.5	67.2	122.2	150.0	174.0	152.6	2.44	162.7
Pruning	21	18.0	13.5	30.0	61.5	129.5	137.8	147.2	139.4	1.67	111.2
Pruning and Nitrate	21	18.2	23.8	36.4	78.4	132.0	242.9	178.4	178.0	2.0	133.3
Nitrate	3	6.6	13.0	19.3	38.3	43.2	132.7	94.6	86.8	3.22	214.6
Montmorency—											
Check	8	36.1	22.8	45.6	104.5	100.	100.	100.	100.	1.26	100.
Heavy Pruning	6	44.8	31.5	68.1	144.4	124.2	138.2	149.3	138.2	1.52	120.7
Pruning	20	38.2	29.5	51.4	119.1	105.8	129.4	112.7	114.	1.35	107.1
Pruning and Nitrate	20	39.2	37.1	56.6	133.9	108.6	162.8	124.2	128.2	1.45	115.0
Nitrate	3	49.5	49.3	63.0	161.6	136.7	226.2	138.1	154.6	1.28	101.5

The productiveness of the trees is more closely related to the way they grow than to the cultural treatment. (Table III.) That is, the same treatment results in different yields on trees that grow differently. On the contrary, trees which grow alike yield very similar crops of fruit even when under different cultural treatments. It can be expected, then, that poorly growing and weakly vegetative trees will be made more fruitful by *any treatment* which increases their growth without materially reducing the fruiting surface. A like amount of care could not be expeted to increase the growth or yield of highly producing trees. The cultural treatment should, then, be based upon the growth condition of the trees.

FERTILIZING AND PRUNING PAY

It is very unusual for poorly cared for trees to be vegetative enough to produce large crops of fruit. As a consequence, pruning and fertilizing to produce the necessary growth has been very profitable. The cost of annual pruning on the experimental plat

was equivalent to the price of one-half to one quart of cherries per tree; that of fertilizing totaled a little more. Since these treatments increased production in excess of this amount they are profitable operations.

INDIVIDUAL TREES CONSISTENTLY LOW OR HIGH PRODUCERS

Some additional effects of the different treatments in the cultural plats were (1) the delayed maturity of fruit on the nitrated trees, (2) the production of some sucker growths on the heavily pruned trees, and (3) the much healthier condition of the wood and foliage of fertilized and pruned trees as compared to check trees. Another significant fact gained from the yield records was the finding of large variation in the yields of individual trees. While uneven production in an orchard is a common fact, it is often considered that the different trees bear in different years. That is, a low-yielding tree is thought to be one that bore heavily the previous season. Yield records of the trees show this is not the case, Table IV. The low-producing trees were found to be consistently light bearers and the heavily producing trees to be, in general, consistently heavy bearers.

TABLE IV. YIELDS ON DIFFERENT RICHMOND TREES, 1919 TO 1921

Plat	Production	Tree number	Quarts per tree			
			1919	1920	1921	Total
Check	Low	164	4	4	10	18
		148	4	5	6	15
		138	7	8	4	19
	High	128	40	23	60	123
		163	34	17	50	101
Nitrate	Low	98	6	10	12	28
Heavy pruning	Low	155	4	8	14	26
		156	3	9	4	16
	High	151	36	32	67	135
		153	36	24	48	108
Pruning	Low	124	4	2	13	19
		127	4	4	8	16
		142	4	5	11	20
		146	7	8	11	26
	High	123	34	30	48	112
		132	48	28	52	128
		133	44	20	62	126
		134	44	25	65	134
Nitrate and pruning	Low	104	5	10	10	25
		106	3	8	14	25
		113	2	5	7	14
		117	4	3	6	13
	High	107	32	52	75	129
		94	42	40	84	166
		97	48	56	91	195
		112	40	48	58	146

HIGH AND LOW YIELDING TREES HAVE DIFFERENT SPUR HABITS

In selecting the data for Table III the lowest and highest yielding trees were chosen. Trees which produced average yields were, however, also consistent in annual production. The cause of the individual variation between trees would not appear to be found in variations in the soil. It is believed that variations in

Fig. 11.—SHADE THE TRUNKS AND PREVENT SOUTHWEST INJURY.

This type of injury results more or less in rapid death of the branches above the wounds and the corresponding loss of fruiting surface. Shading the trunks to prevent alternate freezing and thawing in the spring is an effective preventative. Veneering, boards and building paper are used as shading materials.

the stocks may play a large part in this situation, as the high-yielding trees are in general more vegetative and larger than the low-yielding trees. In some orchards a tree is occasionally found which appears to be growing too much to be very fruitful. There are some trees with "Southwest injury" in the plats (Fig. 11), but this was not consistently related to low production. It did ap-

pear, however, that the type of blossom buds on the trees was very closely associated with their productiveness. Trees with high percentages of spur buds were good producers. This is consistent with the more uniform and particularly the greater production of the Montmorency trees. Trees of this variety have better spur systems than do Richmond trees that have received the same cultural care. Especially in seasons when winter injury of the blossom buds is severe, as in 1920, the trees with many spur buds usually bear much better than the trees with few spur buds (Table V):

TABLE V. RELATION OF PERCENTAGE OF SPUR BUDS TO YIELD, 1920

Variety	Tree	Yield in quarts	Blossom buds	Per cent of buds on spurs
Richmond	134	25	8,860	36.8
	105	26	9,913	45.3
	123	30	11,832	38.7
	94	40	12,218	54.3
Montmorency	73	30	10,304	31.2
	43	30	11,283	38.8
	36	37	13,303	53.8
	81	43	15,550	59.0

RELATION OF WINTER INJURY OF BLOSSOM BUDS TO BUD DEVELOPMENT

Observation of the occurrence of winterkilling of the blossom buds has led to the belief that this trouble is also very largely related to the growth condition of the trees. It was found that the blossom buds which are most advanced in development at the beginning of winter are most subject to winterkilling. An important fact from the cultural viewpoint is that, in general, the greatest development of the blossom buds before winter occurs on trees which make little growth. Likewise, the least development of the blossom buds and consequently the hardiest buds are on the trees which make the most growth. It is apparent, then, that a cultural system which was planned to check the wood growth of the trees early in the season would cause greater development of the blossom buds. Thus, early maturing hardy *branches* would be secured, but the advantage might be greatly outweighed because tender *blossom buds* resulted at the same time. It seems advisable to keep the trees growing later in the summertime than

is the common practice, thus securing hardy blossom buds, but taking a chance of having winterkilling of the wood. There is no evidence that there is much danger of killing back of the new growths during the winter unless they are at least two feet in length. Further, there is little probability of older bearing trees making this much growth under the climatic conditions usually prevailing in Wisconsin.

It has also been found that the blossom buds on spurs are hardier than those borne laterally along the longer growths (Table VI):

Table VI. Bud Injury of Lateral and Spur Blossoms, 1918 to 1920*

Variety	Injury		Av. Blos. per bud		Blos. per 100 buds	
	Laterals	Spurs	Lateral	Spur	Lateral	Spur
Richmond	80.9	40.8	1.76	2.39	33.6	141.5
Montmorency	65.6	26.1	1.79	2.24	61.5	165.4

The data in Table VI help to explain how the trees with many spur buds give larger yields than those with few (Table V). The effect of cultural treatments upon blossom bud hardiness are shown by Table VII.

Table VII. Percentages of Dead Blossom Buds on Spurs of Trees in the Cultural Plats

Variety	Plat	1920	1921	Average
Richmond	Check	51.0	41.5	46.3
	Pruned	30.3	39.5	34.9
	Nitrate and pruning	22.3	22.5	22.4
Montmorency	Check	46.8	5.0	25.9
	Pruned	18.0	2.0	10.0
	Nitrate and pruning	11.8	1.0	6.4
Richmond	Poorly Vegetative	62.0	25.0	43.5
	Highly Vegetative	14.8	6.0	10.4
Montmorency	Poorly Vegetative	31.0	3.0	17.0
	Highly Vegetative	7.8	2.0	4.9

A marked reduction in the winter injury of the blossom buds occurred on the pruned and fertilized trees.* The same difference is noted in general on highly vegetative trees as compared to poorly vegetative trees. Another fact in favor of having strong-

Development and Injury of Cherry Buds Wis. Agr. Expt. Sta. Res. Bul. 52.

growing trees is that they usually develop fruits from a higher percentage of blossoms than do the weakly growing trees.

DROPPING OF CHERRIES MAY REDUCE YIELD

In some seasons the premature dropping of the fruits apparently reduces the crop seriously. Some phases of this problem have been considered. One of the principal lines investigated was that of pollination. A large number of hand pollinations were made in 1920 (Fig. 12) in addition to observing insect and wind relations to pollination. The results of 1921 appear practically the same as for the previous season, but are less complete because of frost injury during the late blossoming period. A frost occurring shortly after the pollinating was done injured the blossoms within the bags quite seriously, although it had very little effect upon those which were exposed. Table VIII shows the pollination results of 1920:

Fig. 12.—METHOD OF BAGGING POLLINATED BRANCHES.

This fine type of Richmond tree is just beginning to need some heading back as shown by the arrow. The abundant blossoming follows a long terminal growth and the resulting spur formation. (See Fig. 14.)

TABLE VIII. POLLINATION RESULTS AT STURGEON BAY, 1920

Variety	Pollen or Treatment	No.	Set	Per cent Set
Richmond	Selfed	617	179	29.1
	Montmorency	652	184	28.2
	Morello	487	125	25.7
	Baldwin	130	7	5.4
	Late Duke	92	2	2.2
	Governor Wood	146	15	10.3
	Emasculated—not pollinated	439	0	0.0
	Emasculated—not bagged	293	17	5.8
	Not emasculated—bagged	376	23	6.1
	Check	708	341	48.2
Montmorency	Selfed	480	83	17.6
	Richmond	489	101	20.7
	Morello	233	30	12.9
	Baldwin	60	1	1.7
	Late Duke	52	2	3.9
	Governor Wood	70	4	5.7
	Emasculated—not pollinated	368	1	0.3
	Emasculated—not bagged	407	19	4.7
	Not emasculated—bagged	532	103	19.4
	Check	907	444	48.9

Fig. 13.—RESULTS OF HAND POLLINATION WORK, 1920.

This photograph was taken after the "first drop." The small fruits shown are part of the "second drop." Some of the large fruits may fall later during the "third drop." (A) A branch which was covered with a bag during blossoming (B) A check branch (natural pollination) (C) Emasculated and then self pollinated Early Richmond (D) Emasculated and bagged but not pollinated. (E) Emasculated and left uncovered without hand pollination. The fruits setting are from "wind pollination."

RICHMOND AND MONTMORENCY ARE SELF-FERTILE VARIETIES

The fact of greatest practical interest is probably that the two principal varieties grown, Richmond and Montmorency, are both highly inter-fertile and self-fertile (Fig. 13). This would seem to eliminate any need of planting different varieties together for the purpose of being pollinizers. Other items are:

1. Little pollen is carried about in the wind. The jarring of the blossoms by air currents appears, however, to be of great aid

Fig. 14.—SOUR CHERRY BLOSSOMS HAVE A NATURAL POSITION AIDING CLOSE POLLINATION.
Note the abundant spur formation on the long one-year-old shoots.

to pollination. A very large percentage of the blossoms have a natural position such that pollen would fall from the anthers upon the stigmas and insure pollination (Fig. 14).

2. Pollination appears to take place without the aid of insects. At least in 1920, no pollen carrying insects visited the cherry blossoms during the blossoming period. The few wild bees and honey bees which were present worked in wild flowers, strawberries and apples. Largely the same condition prevailed in 1921.

3. Microscopic examination of the fallen fruits shows that practically all of them had been pollinated.

SETTING OF THE FRUIT IS RELATED TO THE GROWTH CONDITIONS

From the pollination studies it is concluded that the need for cross-pollination is usually of minor importance in securing a set of sour cherries in Wisconsin. Interest in the problem of early falling of the green fruits changed, then, for the time, from a

Fig. 15.—THE PRESENCE OF SPUR BUDS IS CORRELATED WITH PRODUCTION.

This picture clearly and fairly shows the relation of growth and yield. Young trees frequently bear like the branch at the left. This is not because they are young, but because they make more growth than older trees. Unless pruned and fertilized, older trees bear like the branches on the right. (See Fig. 1.)

study of *dropping* to observation of the conditions associated with *setting* of the fruits. In other words, attention was directed towards where the cherries *were* rather than where they *were not*. Looking at the problem from this angle, it was soon found that, as in other seasons, the heavily yielding trees were those with many spur buds (Figs. 1 and 15). This was more pronounced than in some years, as 1921, because of the rather severe injury to blossom buds, especially the lateral blossom buds, in the season previous to 1920. Extensive observations showed that there were no heavily bearing Richmond trees that did not have many spur buds, although 2 or 3 per cent of the trees which had many spurs did not produce large yields in 1920.

Table IX shows a typical case of a high-yielding tree with many spurs (Fig. 16) and a low-yielding tree with few spurs (Fig. 17). The former tree produced over twice the fruit of the latter one (Fig. 18). Practically all of this increase in yield was produced on the spurs. Table IX does not show the full difference in yield, as the fruit on the low-producing tree was riper and larger. Consequently fewer cherries were needed to fill a quart. The fruits of the more vegetative trees ripen more slowly. Also, the cherries on terminals ripen earlier than on spurs, as a rule. A later picking of the cherries on the high-yielding tree would have increased the total yield by 8 to 10 quarts.

TABLE IX. DISTRIBUTION OF FRUIT ON HIGH AND LOW YIELDING RICHMOND TREES, 1920

	Yield in quarts°				Percentage of totals			
Class	Laterals 1919	Young spurs '18	Older spurs	Total	Laterals	Young spurs	Old spurs	Fruits per qt.
High	22.5	22.5	10.5	55.5	40.5	40.5	19.0	301.5
Low	16.75	7.0	1.4	25.15	66.6	27.8	5.6	245.5

° Cherries were "milked," that is, picked off the stems for the cannery.

The relation of yield to the spur fruiting system is less evident in seasons when winter injury of the blossom buds is less severe. The fact that heavy-producing trees bear a large percentage of the crop on spurs is, however, evidence of the relative importance

Fig. 16.—TYPE OF HIGH YIELDING RICHMOND, 1921.
Note the strong vegetative growth, 12 to 18 inches, and relative openness of top. These conditions favor spur production and longer life of the spurs. (See Fig. 11; also Fig. 14.)

of the spurs in securing large yields. This is especially pronounced in high-yielding Montmorency trees (Table X), even in years when the laterals bear well.

TABLE X. DISTRIBUTION OF FRUIT IN RELATION TO YIELD, 1921

Variety	Yield in quarts			Percentage of total	
	Total	Laterals	Spurs	Laterals	Spurs
Richmond	13	9.5	3.5	73.1	26.9
	34.5	26.	8.5	75.4	24.6
	47.	32.	15.	68.1	31.9
	48.	32.	16.	66.6	33.3
	60	39.5	20.5	65.8	34.2
Montmorency	59.	22.5	36.5	38.1	61.9
	62.	22.	40.	35.5	64.5
	71.5	27.5	44.	38.4	61.6
	76.	30.	46.	39.5	60.5

Fig. 17.—TYPE OF LOW YIELDING RICHMOND, 1920.

Such trees make a weaker growth, 6 to 10 inches and generally have thick, dense tops. Spurs neither form nor live long in such conditions. (See Fig. 16.)

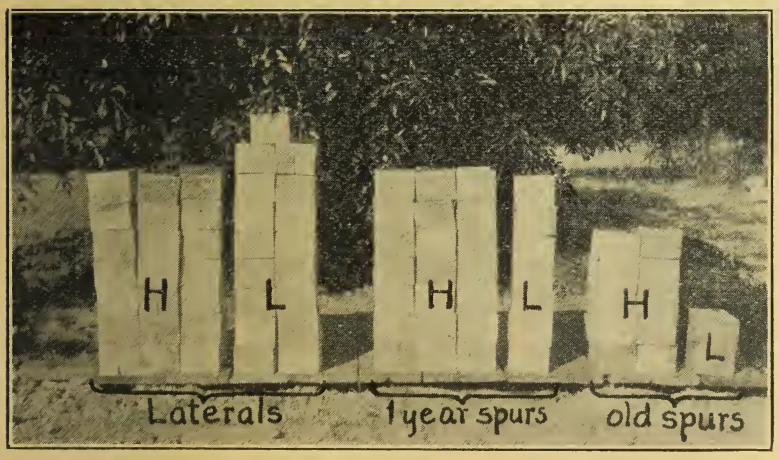

Fig. 18.—CHERRIES FROM HIGH AND LOW YIELDING RICHMOND TREES, 1920.

The boxes from the high producing tree are marked "H" and those from the low producing tree "L." Note the marked difference in yield from spurs. There is relatively little difference in production from the lateral blossom buds.

MONTMORENCY SPURS BEAR BETTER THAN RICHMOND SPURS

Table X calls attention again to the fact that Montmorency is, in general, a heavier fruiting and more consistently fruitful variety than Richmond. The data in Table XI indicate how this occurs, in part. While this latter table does not show that the

Fig. 19.—MONTMORENCY SPURS FROM BLOSSOM BUDS WHILE BEARING FRUIT.

Note the large number of leaves. A bud forms with nearly every leaf. Compare with Fig. 20.

individual spurs live and fruit longer on Montmorency, it does show that the spurs of this variety tend to form blossom buds the same season they are in bearing (Fig. 19) and that Richmond spurs form relatively few buds at the same time they are bearing fruit (Fig. 20). This shows the importance of having a fruiting system in process of being continually renewed in Richmond if consistently high yields are to be secured.

TABLE XI. PRODUCTION AND BUD FORMATION ON SPURS, 1920

Variety	Age of wood producing spurs	Per cent spurs fruiting	Fruits per spur	Fruits per 100 spurs	Per cent fruiting spurs forming buds	No. per spur	Per cent non-fruiting spurs forming buds	No. per spur	New buds per 100 spurs°
Richmond	1918 growth	85.5	3.47	304.7	38.5	2.43	29.0	1.98	88.3
	Older spurs	39.0	2.39	93.2	90.0	3.22	76.5	3.57	279.7
Montmorency	1918 growth	92.5	3.84	355.2	84.5	2.85	69.0	2.89	235.7
	Older spurs	69.0	2.99	206.3	92.0	3.25	89.0	3.21	294.8

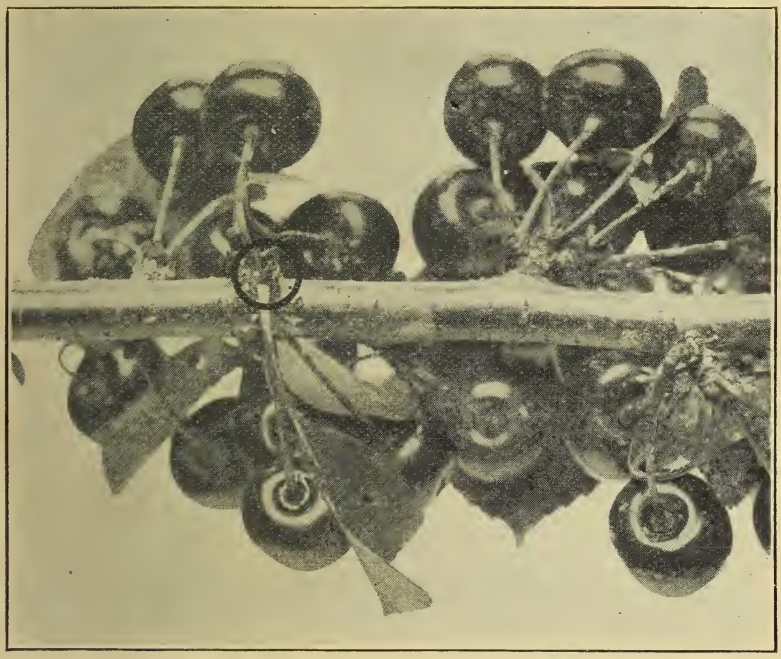

Fig. 20.—RICHMOND SPURS RARELY FORM MANY BLOSSOM BUDS WHILE BEARING FRUIT.

Note the few leaves present. Buds form only in the axes of the leaf stems. Compare with Fig. 19. Large yields on Richmond depend upon having some new spurs formed each year.

CULTURAL TREATMENTS AFFECT THE SET OF FRUIT

As the set of fruit seems to be related to the growth of the trees, it would be expected that any cultural treatment which would modify the growth would also affect the setting of the fruit. (Table XII.)

° Not counting the new spurs that formed on 1919 wood during the growing season of 1920.

TABLE XII. SET OF FRUIT ON CULTURAL PLATS, MONTMORENCY

Plat	Number of fruits per 100 blossoms			
	1919	1920	1921	Average
Check	31.9	30.9	32.4	31.7
Heavy pruning	48.8	44.8	43.7	45.8
Pruning	39.7	39.2	42.6	40.5
Nitrate and pruning	49.2	42.9	43.3	45.1

Marked effects upon the percentage of blossoms setting fruits are apparent, even in the first year of treatment, 1919. The use of a nitrogenous fertilizer on moderately vegetative trees seems to have a very marked effect in increasing the setting of fruit. Further definite evidence of this was secured by a grower who used both 2 and 4 pounds of nitrate of soda per tree in comparison to no commercial fertilizer. The results follow: Per cent of set on check plat, 32.8; where 2 pounds of fertilizer were used, 43.4 per cent, and with 4 pounds, 44.7. In the case of very vegetative trees the effects are generally less marked. In fact, the set of fruit on such trees appears to be near a maximum, so fertilization maintains rather than increases the percentage set in such a case. Under average cultural conditions the percentage set of fruit on a tree is found to be closely related to the yield. That is, the stronger growing trees generally set and mature more fruits than the less vegetative ones. Exceptions are, however, sometimes found; see Table XIII. The causes of these variations and their practical significance are being made the subject of further study.

TABLE XIII. SET OF FRUIT ON INDIVIDUAL TREES, 1920

Variety	Plat	Yield quarts	Fruits per 100 blossoms
Richmond	Heavy pruning	8	10.1
	Check	11	15.0
	Pruning	11	15.02
	Check	23	29.4
	Heavy pruning	24	38.73
	Pruning	25	42.4
	Nitrate and pruning	26	29.34
	Nitrate and pruning	52	51.61
Montmorency	Check	20	30.48
	Check	22	31.17
	Pruning	30	36.1
	Nitrate and pruning	31	45.32
	Heavy pruning	35	39.4
	Pruning	37	42.2
	Nitrate and pruning	57	40.5

Very large numbers of blossoms generally result in heavy early dropping of the immature fruits. Pruning may have part of its stimulating effect upon setting through reducing the number of blossoms and as a consequence increasing the opportunity to set. Even after causing a reduction in fruiting surface larger crops are produced. This leads to a consideration of the time to expect effects upon production after having varied the cultural practices.

Two Years Before Maximum Effects of a Cultural Treatment Appear

Frequently a grower changes his cultural practices almost every year because maximum crops were not secured immediately after each trial treatment. Figures 1 and 15 indicate that the yield — both heavy and light — was largely determined by the amount of growth made two years before the cherries were borne. To bring this more clearly to mind, data similar to that on pages 12 and 15 of the pruning bulletin* are presented in Table XIV:

Table XIV. Relation of Length of Growth to Percentage of Leaf Buds, 1917 to 1920

Length, Inches	4	6	8	10	12	14	16	18
Richmond	0.8	2.5	12.5	25.3	39.3	59.4	78.3	83.7
Montmorency	3.1	4.7	15.6	29.9	56.9	74.8	80.8	92.5

From this table it is clearly apparent that a growth of 15 to 16 inches is needed if large numbers of leaf buds are to be formed. The importance of having these buds lies in the fact that spurs grow only from leaf buds. Blossom buds produce no spur growth. It is clear, then, that a long terminal growth in any season, as in 1918, results in spur production a year later, such as in 1919, and fruit production two years later, such as in 1920 (Fig. 15). In other words, a change from poor to good culture is principally evident only after two or three seasons. Likewise, a change from sufficient to insufficient culture may be clearly evident in reduced yields only after some seasons.

Blossom bud formation varies somewhat from season to season. That is, a six or seven inch growth will have many leaf buds one year whereas similar lengths will have few to no leaf buds

* *Prune the Cherry Trees.* Wis. Agr. Exp. Sta. Bul. 298.

in another year. As a rule the growths in the top of the tree will have more leaf buds on a given length than those around the bottom. There is also a difference in blossom bud formation in different trees. Poorly vegetative trees will generally have fewer leaf buds per unit length than will strongly vegetative trees. It is believed, however, that enough evidence is available to indicate clearly that a consistently strong growth generally results in consistently heavy bearing.

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